BULLETIN NO. 32.

EIGHTH

ANNUAL REPORT

OF THE

AGRICULTURAL

EXPERIMENT STATION

OF THE

AGRICULTURAL COLLEGE

OF

MONTANA

FOR THE YEAR ENDING JUNE 30, 1901

BOZEMAN CHRONICLE PRINT
1902

CONTENTS.

LETTER OF TRANSMITTAL.

BOZEMAN, MONTANA, January 29, 1902.

To His Excellency, JOSEPH K. TOOLE,
Governor of Montana.

DEAR SIR:—In accordance with the Congressional act of March 2, 1887, I have the honor to transmit herewith the eighth annual report of the Montana Experiment Station for the fiscal year ending June 30, 1901.

Very respectfully,
S. FORTIER,
Director.

MONTANA AGRICULTURAL

EXPERIMENT STATION

BOZEMAN, MONTANA.

STATION STAFF.

S. FORTIER, Ma. E.	Director and Irrigation Engineer
F. W. TRAPHAGEN, Ph. D., F. C. S.	Chemist
ROBT. S. SHAW, B. S. A.	Agriculturist
J. W. BLANKINSHIP, Ph. D.	Botanist
R. A. COOLEY, B. Sc.	Entomologist

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

REPORT OF THE TREASURER.

The Experiment Station of the Agricultural College of the State of Montana in account with the United States appropriation, 1900–01.

DR.

To receipts from the Treasurer of the Uuited States as per appropriation for fiscal year ending June 30, 1901, as per Act of Congress approved March 2, 1887	$15,000.00

CR.

By Salaries	8,129.38
Labor	3,000.00
Publications	1,518.31
Postage and stationery	171.62
Freight and express	286.37
Heat, light, water and power	266.45
Chemical supplies	89.82
Seeds, plants and sundry supplies	477.05
Fertilizers	9.50
Feeding stuffs	73.47
Library	116.25
Tools, implements and machinery	422.10
Furniture and fixtures	162.50
Scientific apparatus	277.18
Total	$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana for the fiscal year ending June 30, 1901; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursements $15.000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Signed:

Attest:
PETER KOCH,
Custodian.

JOHN M. ROBINSON,
PETER KOCH,
Auditors.

REPORT OF THE DIRECTOR.

The past year has been one of the most successful in the history of the Experiment Station. The various lines of work that were begun in the past have not only been maintained and their scope and usefulness extended, but new investigations have been undertaken. Each member of the Station Staff has striven to promote the particular industry which he represents, but at the same time there has been a disposition on the part of all to work harmoniously together for the two-fold purpose of benefitting the Montana farmer and building up a great experiment station. The prevailing sentiment among the Station workers is one of confidence in the present, and faith in the future. It is felt that this Experiment Station will soon occupy its rightful place at the head of the Agricultural College and lead the State in all those varied and important industries which are usually grouped under the term of agriculture.

AGRICULTURE IN MONTANA.

It is a great privilege to assist in laying the foundation of what is destined to become the chief source of wealth to many millions of human beings. This State has been one of the last to develop its agricultural resources, but having now made a good start in this direction we believe that few states in the Union will be able to keep pace with it. There are good reasons for such belief. The State is well watered. Under arid conditions the

water supply is of first importance. Such streams as the Yellowstone, Madison, Jefferson and Missoula, the combined summer flow of which would irrigate one and a half million acres, are for the most part unutilized. The native grasses cannot be excelled. When these fail it needs but the thrifty farmer and the irrigation stream to convert the native meadows into productive alfalfa fields. With extensive pasture lands on the mountain slope and alfalfa stacks dotting the valleys, the stockmen should lead every state in the Union. Montana is also admirably adapted to diversified farming. The large yields of vegetables and fruits, grains and fodders that have been harvested for the past few years on the Station farm prove this fact. It will also become in time we believe, one of the leading dairy states. Wisconsin has made wonderful progress in the creamery industry. Last year the value of this product amounted to 22 million dollars. Yet, judged impartially, Montana is capable of surpassing Wisconsin in the production of butter and cheese.

THE WORK OF THE STATION.

Having faith in the agricultural possibilities of Montana the Station officers are endeavoring to so plan and perform their work as to accomplish the most lasting benefits to the people of this State. A skilled mechanic must have tools and appliances before he can perform his allotted task. In like manner the Station scientist needs equipment. Several years have been spent in securing apparatus, fitting up laboratories, making collections and training assistants. This preliminary work is not yet completed, but enough has been done to enable the several departments to do good work along certain lines.

The chemical department is one of the best equipped and the excellent results which it has accomplished have fully justified the expenditure. Most of the knowledge that we now possess of the injurious ingredients in Montana soils, the analysis of potable waters, the adulteration of foods and the excellent quality of the Montana sugar beet has been derived from the Station chemist.

Through the untiring efforts of the agriculturist the Station farm has been transformed from a weed producing tract to a model farm, and his feeding experiments with domestic animals have attracted the attention of all Western stockmen.

The head of the botanical department has spent years of arduous toil in collecting specimens for its herbarium. He has now over 10,000 specimens of neatly mounted plants, forming one of the best collections in the West. During the past year considerable time has been given to injurious weeds and plants poisonous to stock.

The department of entomology was only recently established and in consequence much was required to be done in fitting up a laboratory, indexing the literature pertaining to the subject and making a collection of the insects injurious to the farmer and horticulturist.

The horticultural department is continuing to advance the interests of that important industry. Varieties of all kinds are being tested and those that prove the best are distributed in small lots at low figures among the home-builders of the State.

The poultry buildings and yards are now fairly well equipped and although a comparatively small amount of money has been expended on this industry, the character of the results has been excellent.

Through the liberality of the last State legislature an appropriation of $2,500 was made to erect and equip a dairy. It is earnestly believed that the State will receive in the years to come one hundred fold from this investment.

In recognition of the fact that the Experiment Station is the only irrigation bureau in Montana the last legislative assembly voted the sum of $2,000 to be expended in collecting data on irrigation. If one may judge from the nature of the correspondence which reaches this office, the irrigation investigations conducted by the Station have been highly valued by the irrigators of Montana.

CHANGE IN STATION POLICY.

The most important change in the policy of the Station has been made in the interests of the stockmen of the State. The feeding experiments with both sheep and cattle were carried on last winter in car load lots and sold in the principal markets. By this means a larger number of individuals were included in each test, the shrinkage in shipping as well as the actual expenses, selling prices and profits were determined.

The live stock owned by the Station has also been greatly improved. The scrub swine have been sold and replaced by thoroughbreds, the poorest cows have been exchanged for high grades and a sum of money set aside from both the College and Station funds for the purchase of thoroughbred Shorthorns and Herefords, as well as Rambouillet, Lincoln and Shropshire sheep.

The field of investigations has also been broadened. For a number of years nearly all the experiments were conducted either on the Station farm or in the immediate neighborhood. Farmers in other parts of the State formed the opinion that the Montana Experiment Station was established for the sole benefit of Gallatin county and not for the entire State. At the present writing there are over sixty farmers in different sections of Montana co-operating with this Station in the raising of grains, vegetables, legumes and grasses. The work of the chemist, agriculturist, botanist, entomologist and irrigation engineer have also been extended and include, as far as means and opportunity will permit, the entire State.

Greater freedom of action has been accorded the Station officers in performing the work alloted to each but with this privilege has been given greater responsibility. The harmony and good feeling that have prevailed as well as the excellent character of the work performed seem to have shown the wisdom of this change.

STATION STAFF.

With one exception there have been no important changes in the personnel of the Station staff during the year. Mr. S. M. Emery, who occupied the position of director and horticulturist for a number of years, resigned June 30, 1900, and the writer was appointed to succeed him. My term of office, as director, began, therefore, with the fiscal year just closed. In addition to my duties as director I was also placed in charge of the civil engineering course of the College and the irrigation department of the Station. Under such circumstances it was deemed advisable to group the work of the Station into several departments and place a competent Station officer at the head of each. In this way the head of each department could be held directly responsible not only for the character of the investigations conducted under his supervision, but also for the extent and quality of the contributions and publications.

Dr. F. W. Traphagen retained his position as Station chemist and supervised all sugar beet investigations within the State as well as the investigations pertaining to the adulteration of foods which were made in co-operation with the Bureau of Agriculture, Labor and Industry of Montana.

Prof. R. S. Shaw was placed in charge of the Station farm and given the care and management of all live stock. His most important duties were to conduct experiments in grain raising, forage crops and stock feeding.

Dr. J. W. Blankinship continued to act in the capacity of Station botanist and in addition to the labor involved in collecting specimens of the economic plants, investigated the plants poisonous to stock and the injurious weeds of the state.

Prof. R. A. Cooley succeeded himself as entomologist of the Experiment Station and inspector-at-large to the State Horticultural Board.

The horticultural department was placed in direct charge of Mr. Charles Wilson, who was to act under the supervision of the agriculturist and the director.

Mr. H. C. Gardiner was continued in charge of the subdepartment of poultry.

All irrigation investigations and water supply measurements were placed under the supervision of the director.

STATION COUNCIL.

The members of the Station staff have held meetings once a month for the purpose of considering matters pertaining to the welfare of the Station. The candid expression of opinions at these meetings on all topics of vital interest has greatly aided the director and executive board to adopt wise measures in regard to plans for future work and the expenditure of Station funds.

NEEDS OF THE STATION.

I désire to call the attention of the members of the governing boards to the urgent needs of the Experiment Station.

In the first place it has no barns, granary or outbuildings worthy of the name. In this respect we rank below every other station in the Union. All our feeding experiments have had to be done under the most laborious and primitive methods. Our agriculturist has done splendid work in raising hundreds of varieties of grains. These have to be stored in log buildings and the mice cause endless trouble in mixing the varieties.

For the past two years the water supply for irrigation has been deficient. During the past season the flow was frequently less than 40 miner's inches for 160 acres of land. An additional supply of at least 25 miner's inches is required. More water is needed for experimental purposes than for ordinary farming.

It would also add greatly to the appearance and utility of the Station farm if a tract of land of about 10 acres, now unoccupied and for sale, located at the northeast corner of the farm could be purchased. In feeding sheep and cattle in car load lots it is difficult to raise enough feed on our limited area and likewise provide experimental tracts for the several departments as well as pasturage for live stock.

The present Station building is over crowded and provision must soon be made for additional class-rooms for farmers' boys who attend during the winter months. More space for laboratories and offices is also needed. The heating plant is now in the

basement of the main building with no facilities for extinguishing fires. There should be a separate heating building.

The Experiment Station should have a skilled veterinarian, thoroughly competent to undertake the bacterological investigations of animal diseases. The stockmen of the State and the State veterinary surgeon desire it. Dr. M. E. Knowles has rendered valuable services to the State in many ways, but particularly in preventing the spread of animal diseases. The territory is so vast and the number of domestic animals so great that his time is fully occupied in police duties and the identification of diseases. It is of the utmost importance to the stock interests of Montana that this Station supplement the valuable work now done by the State veterinarian.

PUBLICATIONS.

The following bulletins have been published during the year. Of these, numbers 25, 26 and 27 belong to the previous year.

No. 25. Paris Green and London Purple in Montana, by F. W. Traphagen.
No. 26. Poultry Raising, by H. C. Gardiner.
No. 27. Live Stock Feeding Tests, by R. S. Shaw.
No. 28. Seventh Annual Report.
No. 29. The Quantity of Water Used in Irrigation, by S. Fortier.
No. 30. Weeds of Montana, by J. W. Blankinship.
No. 31. Grazing and Feeding Tests, by R. S. Shaw.

FARMERS' INSTITUTES.

Through the efforts of the friends of agriculture a bill providing for the holding of Farmers' Institutes was passed by the last legislative assembly and received the approval of the Governor March 14, 1901. The Board of Administration consists of the Governor of the State, the presidents of the Montana Wool-Growers' Association, the Montana Live Stock Association and

the Montana Horticultural Society and the director of the Montana Experiment Station. Provision is also made to add the presidents of the dairy and agricultural associations to the board when these latter associations are organized. The Administrative Board is required to meet in November of each year to make the necessary arrangements to hold institutes during the winter months and also in March to arrange for the publication of the proceedings in a Farmers' Institute Annual.

The annual appropriation is $2,000, but since a large portion of this sum will be expended in reporting and publishing the proceedings the balance will scarcely be sufficient to pay for traveling and incidental expenses.

The members of the Administrative board met in Helena June 10, 1901, and organized by electing A. L. Stone, of Missoula, president and S. Fortier, of Bozeman, secretary. On account of the lack of funds it was decided not to appoint for the present a superintendent of Farmers' Institutes and the secretary was given authority to arrange the dates and places of meeting as well as to secure voluntary speakers for each county institute.

CORRESPONDENCE.

The correspondence of the Station is increasing rapidly. This may be regarded as a true index of the interest that is being taken in experiment station work in Montana. During the year over 2,500 letters have been received and answered. A large number of these came from the rural districts of the State. Many of the letters received from farmers and stock men required considerable time to answer for the reason that there were no Station circulars or bulletins which contained the desired information. As the number of the Station publications increase a greater variety of topics will be discussed and we hope to have in the near future more information to send to our correspondents.

Meanwhile we beg to assure all those who are interested in agricultural pursuits that we will cheerfully do what we can to reply to their enquiries and we hope that the farmers of the State will avail themselves of this opportunity of obtaining such information as this Station can give.

EXCHANGES.

Agricultural Experiments, Minneapolis, Minn.
Agricultural Epitomist, Spencer, Ind.
American Fancier, Johnston, N. Y.
Avant Courier, Bozeman, Mont.
Baltimore Sun, Baltimore, Md.
Belt Valley Times, Belt, Mont.
Big Timber Pioneer, Big Timber, Mont.
Beet Sugar Gazette, Chicago, Ill.
Billings Times, Billings, Mont.
Bozeman Chronicle, Bozeman, Mont.
Butcher's Advocate, Chicago, Ill.
Carbon County Chronicle, Red Lodge, Mont.
Chicago Drover's Journal, Union Stock Yards, Chicago, Ill.
Commercial Poultry Journal, Draper Pub. Co., Chicago Ill.
Dairy and Cream, 315 Dearborn St., Chicago, Ill.
Dillon Tribune, Dillon, Mont.
Elgin Dairy Report, Elgin, Ill.
Farmers' Guide, Huntington, Ind.
Farm Home, Springfield, Ill.
Farm Journal, Philadelphia, Pa.
Farmers' Institute, Chicago, Ill.
Farm News, Springfield, Ohio.
Farmers' Review, Chicago, Ill.
Farm Poultry, Boston, Mass.
Farm Stock and Fireside, Sioux City, Ia.
Farm Stock and Home, Minneapolis, Minn.
Feather, Washington, D. C.
Florist's Review, Chicago, Ill.
Gallatin County Republican, Bozeman, Mont.
Glendive Independent, Glendive, Mont.
Garden and Farm, Chicago, Ill.
Home and Farm, Springfield, Mass.
Home and Garden, St. Paul, Minn.
Horticultural Visitor, Kinmundy, Ill.
Holstein Register, Brattleboro, Vt.
Independent, Helena, Mont.
Inter-Mountain, Butte, Mont.
Industrialist, Manhattan, Kan.
Inter Lake, Kalispell, Mont.
Inland Poultry Journal, Indianapolis, Ind.
Irrigation Age, 916 W. Harrison St., Chicago, Ill.
Jersey Bulletin, Indianapolis, Ind.
Livingston Post, Livingston, Mont.

Madisonian, Virginia City, Mont.
Milwaukee Journal, Milwaukee, Wis.
Mining World, Butte, Mont.
Montana Fruit Grower, Missoula, Mont.
Modern Farmer, St. Joseph, Mo.
National Stockman and Farmer, Chicago, Ill.
Northwestern Poultry and Pets, Spokane, Wash.
Ohio Farmer, Cleveland, Ohio.
Opportunity, St. Paul, Minn.
Orange Judd Farmer, Marquette Building, Chicago, Ill.
Park and Cemetery and Landscape Gardening, Chicago, Ill.
Progressive Farmer, New Port, Va.
Plainsman, Plains, Mont.
Poultry Culture, Kansas City, Mo.
Poultry News, Lincoln, Neb.
Poultry Herald, St. Paul, Minn.
Poultry Journal, Spokane, Wash.
Pacific Poultrymen, Tacoma, Wash.
Rural Spirit, Portland, Ore.
Rural New Yorker, New York, N. Y.
Rural North West, Portland, Ore.
Reliable Poultry Journal, Quincy, Ill.
Stock Growers' Journal, Miles City, Mont.
Strawberry Specialist, Kittrell, N. C.
Stockman and Farmer, Helena, Mont.
Southern Farm Magazine, Baltimore. Md.
Tribune, Stevensville, Mont.
The Weekly Chronicle, San Francisco, Calif.
The Sentinel, Boulder, Mont.
The World, Vancouver, B. C.
Tribune-Review, Butte, Mont.
Tribune, Great Falls, Mont.
Up-to-Date, Indianapolis, Ind.
Western News, Hamilton, Mont.
Wallace Farmer, Des Moines, Ia.
Wisconsin Agriculturist, Racine, Wis.
Western Fruit Grower, St. Joseph, Mo.
West Virginia Farm Review, Charleston, W. Va.
Western Home Journal and Inter-Mountain, Spokane, Wash.

S. FORTIER,
Director.

AGRICULTURAL DEPARTMENT.

R. S. SHAW, Agriculturist.

Throughout this year the work of introducing and testing varieties of grains, grasses, forage and fodder plants and potatoes has been continued. The fourth season's work in the six year crop rotation has also been successfully completed. Much attention has also been given to culture methods relating to their effects on weed destruction and the maintenance of fertility. Some time and money have also been given to permanent improvement work and land reclamation. The greater portion of my time has been spent in the direct supervision of the farm labor, even to the routine work.

VARIETY TESTING OF GRAINS.

Wheats.—Forty-three varieties were grown under irrigation. These consisted of a few new introductions, the balance of which had been grown from one to several years. The number was greatly decreased this year, some twenty-five or more worthless varieties having been discarded. The average yield from these forty-three varieties was 52.6 bushels per acre, and as the result of this season's work in conjunction with the data secured from previous years five selections were made on the basis of quantity and quality of product. These varieties are: Kubanka, Red Fife, Russian 2955, Wild Goose, Wellmans Fife and McKissocks Fife.

Oats.—These included thirty-three varieties chosen and handled in the same way as the wheats. The average yield was 87.9 bushels per acre. Four selections were made, viz.: Poland White, American White, White Wonder and Nameless Beauty. Two varieties chosen the previous year were increased this season to be put in the hands of farmers in various portions of the State, these were the Nameless Beauty and White Russian. From 1.48 acres the former yielded 129.7 bushels, or 87.3 bushels per acre, while the latter yielded 215.8 bushels from 1.96 acres, or 110 bushels per acre. After cleaning and grading, the White Russian oats weighed 44 pounds per measured bushel. Of these two oats, lots not exceeding five bushels were sent out to fifty farmers in different parts of the State. These were cleaned and graded and sold at the rate of $1.25 per cwt. in response to inquiries for seed. In addition to this smaller trial lots, consisting of a few pounds, were distributed for trial in other locations. From this work we expect to secure returns which will tell us to what extent these varieties have been successful and also where the seed is located.

Barley.—Twenty-four varieties were grown in the same manner as the two preceding grains, giving an average yield of 48.9 bushels per acre. Seven varieties of the brewing kind, imported from Germany, were selected this year. Three kinds of hulless barley, viz.: Black, White and Smooth, selected and increased from previous years, were disposed of to farmers in several sections of the State to be grown for feeding purposes.

Peas.—From some ten or a dozen varieties tested, all have been discarded except two, viz.: Mummy and Canadian Golden Vine. Of these two, the former is a crown pea, an early maturing sort, characterized by a short, strong straw, producing large grain which all ripens at once. The Canadian Golden Vine is an indeterminate grower producing a much longer, more slender and yet heavier yield of straw per acre. These are a later kind. We recommend them where a large quantity of fodder is desired which can be controlled by the water supply. This pea will ripen up and produce an abundance of grain unless grown on moist ground or watered too freely. There has been a greater demand for the seed of these two peas than could be supplied.

Rye.—Some attention has been given to varieties of spring rye with the result that one has been chosen which yields 30.6 bushels per acre and produces a large yield of straw of a fine leafy character.

GRASSES AND FORAGE PLANTS.

Twenty-six grasses have been grown, both with and without irrigation. Though this work is incomplete, and should extend throughout a number of years, some results are being secured as the work progresses. Of the total number, Brome Grass has proved to be the most drouth resistant; it is the first to start in the spring and the last to remain green during the season of drouth, quickly recuperating again in the autumn. It has produced one and one half tons of hay per acre where timothy, under similar conditions with scant soil moisture supply, only produced one half ton to the acre. Many failures to start Brome Grass have been due to the use of poor seed. When the germinating power of the seed is not known it is very difficult to get the right kind of a stand. If the grass comes up too thickly, matting soon results, and the growth becomes fine and spindly. Second in importance, as a drouth resister, followed a native rye grass, but while it possesses these good qualities they are partly offset by a growth somewhat too stemy devoid of leaves. The English and Italian rye grasses were found to be vigorous growers without irrigation, but failed to withstand the severity of the winter. The tenacity of life shown by Blue Grass under these dry conditions was surprising; it makes a remarkable growth early in the season, then dries up and makes a fine nutritious growth in the autumn.

Among the information of practical importance secured in this work was the discovery that the Montana grown grass seeds all possess a remarkably high germinating power, and we believe that the production of grass seeds can be made both practical and profitable.

Of the forage crops Dwarf Essex rape made a remarkably strong growth with one irrigating. It was, however, subject to

attacks from the green aphis which almost totally ruined the rutabaga crop during this same season.

Root Crops.—Of these, mangolds, sugar beets, carrots and rutabagas were grown for feeding purposes. The mangolds gave the largest yield per acre with carrots second and sugar beets third. The rutabagas were almost totally destroyed by the green aphis. These roots were all used for feeding purposes on the farm. The carrots proved to be an excellent food for horses feeding on straw. The mangolds were used for chicken and hog feed and the sugar beets were used exclusively by the hogs. Too much cannot be said in favor of the use of sugar beets for pigs which are being wintered over. They can be fed whole and raw and require little grain along with them to keep the pigs in a thrifty growing condition. From twelve to fifteen tons of sugar beets can be produced from one acre of land at a cost not exceeding $25.00, if properly handled.

Potatoes.—In all fifty-two varieties were tested. In making selections of the best, most attention was given to those producing the largest percentage of marketable potatoes which was determined after culling out the small and large rough ones. It frequently happens that the sorts producing the greatest total yield per acre do not give the highest percentage of a marketable product. The following selections were made, viz.:

Early Varieties.—Six Weeks Market, Acme, Early Ohio, Early Oxford and Early Vaughan.

Medium Varieties.—Rural New Yorker No. 2, Lees Favorite, Snow Drop, American Wonder and Oregon Pearl.

Late Varieties.—White Maine.

ROTATION TESTS.

During this season the fourth trial of the six year rotation experiment was made, with the following result:

YIELDS OF ROTATION ACRES FOR 1900.

Acre of *Wheat*, grain	38.3 bu.
" " " straw	3,000 lbs.
" " *Clover*, hay	3,170 lbs.
" " *Barley*, grain	87.2 bu.
" " " straw	3,980 lbs.
" " *Sugar Beets*	16,310 lbs.
" " *Oats*, grain	75.5 bu.
" " " straw	2,345 lbs.
" " *Peas*, grain	37 bu.
" " " straw	

With the exception of the sugar beets this record shows a steady increase in the productiveness of these six acres during the past four years. This season the sugar beet plants were badly damaged soon after coming through the ground as the result of the ravages of a flea beetle. Some fluctuations occur, due to climatic conditions, but in general the yields are satisfactory. While this is the case, however, the rotation is too wide for practicability.

CO-OPERATION WITH FARMERS OF THE STATE.

Because of the great diversity of conditions, it was found necessary to adopt some means by which the work of the Station could be supplemented in as many other portions of the State as possible. In order to accomplish this, small quantities of grains, potatoes etc. were placed in the hands of private individuals for trial. The only conditions required were that accurate reports would be furnished. No less than seventy co-operators were secured. While results have not as yet been obtained from this work we feel that it will be of great benefit to the farmer directly and will bring much valuable information back to the Station which may be used in a practical way.

LIVE STOCK BREEDING AND FEEDING.

Importations of Berkshires and Poland Chinas were made during the year and both herds established with first-class stock to breed from. In all eighteen sales of breeding hogs were made as follows: In Gallatin county 12, Lewis and Clarke 2 and one each in Madison, Cascade, Missoula and Park.

In addition to these, two sales of breeding bucks were also made.

GRAZING AND FEEDING.

Grazing Trials.—In June of 1900, 5.04 acres was fenced off in two equal parts from an alsike field which had been seeded in 1897. The soil consisted of a deep, rich humus, somewhat loamy with a gravelly sub-soil. The two lots were irrigated alternately every two weeks from June 13th to August 18th and pastured in the same way. Twelve yearling Shorthorn and Hereford steers were chosen for the experiment. They were turned on the clover June 9th, remaining until October 1st. It was thought at first that the steers would be sufficient to consume the clover, but on June 18th it was necessary to add to their number to prevent waste. Consequently seven Jersey grade heifers belonging to the Station were turned in upon the clover also. During the experiment one steer died from bloat and all were removed for a few days while the pastures were wet.

On June 9th the twelve steers which were thin from wintering on the range averaged 545 pounds per head, on October 1st the eleven remaining averaged 783 pounds, making an increase of 3,278 pounds which with the gain of 176 pounds made by the steer before death gave a total increase of 3,454 pounds. The Jersey grade heifers, which were one and two years old, weighed 4,575 pounds on June 18th and 5,681 pounds on October 1st, making a total gain of 1,106 pounds. The relative gains were, therefore, for the steers 2.75 pounds per head per day, and for the heifers 1.69 pounds during the same time and under the same conditions.

This tract of 5.04 acres provided food for maintenance and the gains given, for eleven steers during the equivalent of 108 days, and also for the seven heifers 93 days, after taking into consideration the loss of the twelfth steer and the few days the cattle were removed from the pastures.

A sum total of 4,560 pounds animal increase was secured from the 5.04 acres of alsike clover, which amount valued at four cents per pound, gives a cash value of $182.40, or $36.19 per acre.

FEEDING STEERS FOR MARKET.

Thirty-one steers were fed for shipment, consisting of the eleven steers used in the grazing test and twenty additional yearlings secured from the range. The feeding began November 13th, 1900, when the steers were divided into three lots according to quality. Those from the clover were fed separately.

The food consumed by the steers from November 13th to March 30th was as follows: Lot I (eleven steers) 37,455 pounds clover and 7,530 pounds barley meal. Lot II (ten steers) 29,335 pounds clover and 7,315 pounds barley meal. Lot III (ten steers) 29,235 pounds clover and 7,308 pounds barley meal. The average daily consumption of food, per capita, during 137 days was, for Lot I, 24.8 pounds clover and 5 pounds barley meal; lot II, 21.4 pounds clover and 5.34 pounds meal; lot III, 21.3 pounds clover and 5.39 pounds meal.

The following gains were made during the 137 day feeding period:

Lot I,	eleven steers,	3,015 lbs.	averaging	247.1 lbs.	per capita
" II,	ten "	2,410 "	"	241 "	" "
" III,	" "	2,345 "	"	234.5 "	" "

The average daily gains per capita for the three lots throughout the period were 2, 1.75 and 1.71 pounds respectively.

The large gains from such light feeding are attributed to the superior quality of the food and the extremely suitable climatic conditions. The clover had been cured beneath a cloudless sky

and the feeding period consisted of an almost uninterrupted succession of bright still days. The steers were fed in open yards.

We have found with legumes of such quality as can be produced in our valleys that maximum gains can be secured from the use of a minimum amout of grain. Not more than one half pound, per day, per one hundred pounds of live weight is required.

The foods were charged up at $5.00 per ton for clover and 70 cents per cwt. for barley meal, resulting in a total cost of $146.34 for lot I, $124.53 for lot II and $124.71 for lot III. Therefore from the data given we get the following comparative costs per one hundred pounds increase, viz.: $4.85, $5.16 and $5.31, the cost increasing as the lots lacked in beef type.

These steers were shipped to Seattle, where the sale resulted in a net profit of $122.59 on the car load, notwithstanding the disadvantage of their age, weight and the heavy shrinkage resulting from the five day trip.

SHEEP FEEDING EXPERIMENTS.

Test No. I.—Consisted of three lots of lambs of 53 each, receiving the following rations: Pen (1), clover and grain ration of oats and barley; pen (2), clover and screenings; and pen (3), clover only. The relative amounts of food consumed per head per day were: Pen (1), clover 2.9 pounds, grain .56 pounds; pen (2), clover 2.94 pounds and .55 pounds screenings; pen (3), clover 3.32 pounds. The average gains per head per month throughout the 90 days were: Pen (1) 24.96 pounds; pen (2) 28.08 pounds and pen (3) 21.15 pounds. The relative cost of production per 100 pounds was, pen (1) $4.34, pen (2) $3.34 and pen (3) $3.53. We concluded, therefore, that the most profitable results were secured from the clover and screenings because the increase was greater and the cost of production less. Clover was charged at $5.00 per ton, oats and barley at 85 cents per cwt. and screenings at 55 cents.

CLOVER AND GRAIN HAY COMPARED.

Test No. II.—The same number of lambs was used as in the previous test and under the same conditions. The grain hay consisted of a mixture of oats, peas, barley and spring wheat grown together and cut early in the milk stage. The test was conducted for 60 days and both foods charged up at the price already given for clover.

During these 60 days the clover fed lambs made a gain of 14 pounds per head, while those receiving grain hay gained only 10.68 pounds. The former also produced 100 pounds increase at a cost of $3.63 as compared with $4.60 from the grain hay lot. There was too much waste from the grain hay and we believe that horses or cattle could have used this food to better advantage.

EFFECT OF WATER SUPPLY ON FATTENING LAMBS.

Test No. III.—Two lots with food and surrounding conditions alike were treated differently as to water supply. One had constant access to water in the yard, the other was turned to water but once a day. The lambs with constant access to water gained 9.36 pounds each, per month; the others gained but 7.15 pounds in the same time. Those which were permitted to take water at will produced 100 pounds gain at $3.34 while those with restricted supply cost $4.51 for the same amount.

CORRESPONDENCE.

The correspondence sent out by me from my department for the year amounted to 442 letters. Many of these were answers to inquiries relating to methods of cultivation, seeding, treating seed grain and requests for information relating to the various kinds of farm products. Many inquiries were also made in regard to live stock and methods of feeding.

PRESS CONTRIBUTIONS.

Seventeen articles were contributed to the local press. These treated of subjects relating directly to the agriculture of Montana and presented in greater part some minor results of Station work not sufficiently important to warrant special publications. Some of the subjects presented were: Sheep Feeding in Montana, Stock Feeding Tests at the Experiment Station, Formalin Treatment for Grain Smuts, Alfalfa for Seed, Co-operation Between the Montana Farmer and the Experiment Station, a series of seven articles on Swine Feeding, Utilizing the Waste Products of Western Farms, etc.

FORMALIN TREATMENT FOR GRAIN SMUTS.

About one year ago reports were sent out from the Experiment Station regarding the use of formalin as a preventive of grain smuts. Since that time another year's experience has been added, verifying the work of the three preceding years.

As requests are coming in daily, asking for instructions as to the use of formalin, we find it necessary to again make our reports far-reaching through the kindness of the press of the State.

Though many different methods of treatment for grain smuts have been devised and tried, none have proven to be more perfect preventatives than formalin. It is pre-eminently a germ destroyer and its work is perfect. It does not in any way injure the vitality of the grain. It is a comparatively inexpensive method and is easily applied.

For oat, barley and wheat smuts a mixture of one pound or pint of formalin to forty gallons of water will be effectual. We have used one pound to thirty-five gallons of water without injury. One pound of formalin used in the proportion given will treat from forty to fifty bushels of grain.

Application.—Either the dipping or sprinkling method may be used with good results and the method chosen will depend upon the facilities at hand for doing the work.

Sprinkling Method.—May be used where floor space or a number of sheets are available. The grain should be spread out thin and the moisture applied with a common watering can, while the grain is being constantly shoveled to insure a thorough application, upon which the effectiveness depends. After a thorough application has been made, the grain should be heaped and allowed to stand for two hours before being spread to dry.

Dipping Method.—This is the most sure as the application is likely to be the most perfect. The sacks containing grain can be immersed in a barrel or trough containing the mixture. The grain should be allowed to remain in the sacks at least two hours before being spread to dry. In both cases the grain should be dried perfectly, except when sown immediately after. In all cases the sacks should be treated. With wheat it is only necessary to wet the outer surface of the grain, but with oats and barley, the application should be made to penetrate the hulls, where spores may have found lodgment. This is accomplished by immersing for a few minutes and then allowing the grain to stand in the sacks as directed, or in a pile if sprinkled.

Formalin has also been successfully used for potato scab by immersing the uncut seed for from one to two hours in a mixture of one pound of formalin to thirty gallons of water.

Formalin is also known as formaldehyde and formic aldehyde. It is a powerful germ destroyer and an extremely active substance. It is sold in the liquid form at about fifty cents per pound and can be secured in most of the drug stores of the State. We cannot urge its use too strongly. Farmers in the vicinity of Bozeman, who have used formalin, report favorably.

WASTE PRODUCTS OF WESTERN FARMS MAY BECOME A SOURCE OF PROFITABLE GAIN THROUGH THE USE OF LIVE STOCK.

After the season of harvest is past, the work of threshing completed and the crops removed for storage or shipment, large quantities of food products still remain on the western farm. While the enormous crops of grain are being secured, there is

always some loss occuring during the process of harvesting, handling and threshing, thus leaving some grain on the fields of even the most careful farmer. These losses are due to the falling of many heads of grain from the sheaf in harvesting or subsequent handling; or, because of their plumpness and weight, some break loose from the stem and are lost; in other cases, again, innumerable grains "shatter out" and fall to the ground as the result of climatic effects peculiar to the arid west. Thus, it follows that much grain remains on the stubble field. It is to these we refer as "waste products," and such they are, unless recovered and converted into a marketable product. And it is through the use of live stock only that they can be turned to profitable account.

In addition to the grains left among the stubble, the meadows or clover fields provide a late growth, which may be used by some kind of stock. Then there are always some weeds and grasses, found bordering along ditches, fences and roads, which can be made use of.

On the majority of western farms no return is secured from these so-called waste materials, except such as is picked up by a few swine on an occasional ranch. The greater portion of this material is, however, generally lost.

In securing lambs, prior to the time of winter feeding, the Montana Experiment Station was enabled to obtain data which gives valuable information relating to the relative capabilities of cattle, sheep and swine, to utilize the waste products of the farm and also the return which could be secured from it.

After the crop had been secured, one hundred and twelve acres of the Station farm became available as a run for stock. This area consisted of stubble from 14 acres of oats, 7 acres wheat, 10 acres barley, 12 acres field and garden peas, 4 acres plat grain, 4 acres grain hay and 4 acres root and potato ground. The balance comprised 57 acres clover stubble, 5 of which had been pastured closely throughout the season and two cuttings removed from the remainder. The barley and wheat stubble grounds both possessed good stands of clover.

On October 4th, 11 yearling steers, 8 Jersey heifers, 3 colts and 25 pigs were given access to the fields. And on October 15th 230 lambs were added. This stock continued on the fields until November 15th.

The 11 yearling steers were put on the fields at a weight of 8,613 pounds, averaging 783 pounds. They were removed to the feed yards on November 15th, weighing 9,060 pounds, with an average of 823. During the 42 days, these steers required 3,344 pounds hay, because of frosts and storm, in addition to the waste materials consumed. Therefore the 447 pounds gain made by the steers, at 4½ cents a pound, is worth $20.11, which sum, minus the hay consumed, viz.: 3,344 pounds at $6.00 per ton, gives a profit of $10.08 gain from the steers, from increase in weight, in addition to food required for maintenance.

The 230 lambs went on the fields on October 15th, weighing 11,699 pounds with an average of 50.86 pounds. On November 15th these were removed to the feed lots, after having weighed 13,948 pounds, averaging 60.64 pounds. We therefore have a total increase of 2,249 pounds of mutton, or 9.78 pounds per head. The increase of 2,249 pounds, at 5 cents, gives a return of $112.45, minus 1,100 pounds clover hay at $6.00 per ton, leaving a clear profit of $109.15 from the lambs consuming waste farm products.

The 24 pigs, consisting of Berkshire and Poland China sows and young stock, were turned on the stubble fields on October 4th. They then gave a total weight of 2,731 pounds, averaging 113.79 pounds, including all ages.

On November 15th, these pigs were prevented from securing further supplies from the fields by severe weather. They were then found to weigh 3,608 pounds, an increase of 877 pounds over the weight at the time of going on the stubble. During this time 410 pounds of barley meal, at 60 cents per cwt., was fed in time of storm, amounting to $3.28. The 877 pounds gain, at 5¼ cents per pound, gives a return of $46.04, which sum minus the value of the food fed, amounting to $3.28, leaves a clear profit of $42.76 from the 25 pigs while consuming waste grain. And this is, of course, over and above the food required for maintenance.

We regret that data was not secured relating to the colts and and Jersey cattle.

From a financial standpoint, a clear profit of $161.99 was obtained from the cattle, sheep and swine, as follows: $109.15 from 230 lambs, $10.08 from 11 steers and $42.76 from 25 pigs.

Nor is this all, for no account is made of the value of the waste products secured and used for maintenance of the animals. We have considered only the value of the actual pounds of flesh produced, and have also given credit for the supplementary food used.

Attention is called to the percentage rate of increase, in pounds, of cattle, sheep and swine feeding on waste materials, including the supplementary foods fed. As the original weight of the steers was 3,613 pounds, and 447 pounds increase was made, the percentage rate of increase was 5.19 per cent. The original weight of the lambs being 11,699 pounds, and the increase made 2,249 pounds, the percentage rate of increase was 19.2 per cent. In the case of the swine an increase of 877 pounds was added to the original weight of 2,731 pounds, giving a percentage increase of 32.1 per cent. The 3,344 pounds of hay fed to the 11 steers was just sufficient to supply their needs 12 days out of the 42; the 1,100 pounds of clover fed the 230 lambs during the month was used during a stormy period of 2½ days. The 410 pounds barley meal was required by the pigs during a similar stormy period when they were off the fields. In the case of the lambs the hay fed would not account for more than 100 pounds increase, and the grain fed to the hogs not more than 70 pounds.

These results show conclusively that sheep and pigs, both being close feeders, are better able to recover the waste products of the farm than cattle. And that the three can be used together to best advantage. That under the conditions described, steers are enabled to maintain themselves for a long period, but the gains will not be great. While the pig secures most of the fallen grain, the sheep, with appetite suited to a limitless variety, gleans from all sources alike, securing grain, grass, weeds and late pasture growths.

The sole benefit is not derived entirely from a monetary standpoint, but from the most thorough cleaning which the farm receives, especially from the sheep, which does the work of the scavenger in handsome fashion. They more than pay their way by the weed seeds which they destroy. There are few plants that the sheep will not eat if allowed access to them before they become dead and woody. And any weed seeds consumed by them do not

escape being destroyed. While the pigs secured their food mostly from shattered peas and wheat, the lambs consumed all classes of waste grain and vegetation. During the time the stock was on the fields 55 acres of the tract was plowed, as late as possible, for spring sowing beginning first with those possessing least food.

Where clover can be grown, sheep can be used most advantageously in gathering the waste products of the farm. Coming from the scant range they are thus prepared to go on winter feed in good form. Strange to say, no losses have occured during two seasons from sheep and lambs grazing on frozen pastures, even though death from bloating has caused serious loss earlier in the season. This experience, with regard to late grazing on clover, is also supported by that of others in the valley. Contrary to eastern experience our clover pastures come out in better form in the spring when grazed off late in the fall. Luxuriant growths remaining on the fields seem to cause smothering or winter killing. The fields are also benefitted by the return of much fertilizing material.

As the result of utilizing the "waste products" of 112 acres on a Montana farm, by the means of live stock, we have a clear profit of $161.99 or $1.44 per acre over and above the value of the food secured by the animals and required for maintenance. And And these profits resulted practically without any expenditure for labor. If all the waste products of western farms were thus utilized they would become a source of revenue of great magnitude. The best financial successes result from securing all the revenue obtainable from these apparently worthless and insignificant sources.

FATTENING LAMBS ON CLOVER IN GALLATIN VALLEY.

The Gallatin valley has long been famous for the production of brewing barley, wheat and oats, of unsurpassed quality. The conditions giving rise to such favorable results have been known to find their source in a deep, rich, easily worked soil, with an abundance of water for irrigation, and climatic conditions which

bring all the forces of nature into harmony in the perfect development of these products. But while the production of these grains is unsurpassed, both in quantity and quality, the same conditions which favor their growth produces marvelous results in the production of clover. As the result of experiments along this line, the Experiment Station has secured much valuable data relating to the growth of clover, its effect on the fertility of the land, and utility as a food factor. These facts will appear in future publications. And while the Station most earnestly advocates the growth of clover in Gallatin valley, the constantly increasing area has lead to another important question, viz: The most economic use which can be made of clover in order to secure the greatest possible return from it.

Two years ago experiments were conducted in lamb feeding, in which alsike, red clover, and alfalfa were the chief foods used. Careful comparison showed these three to possess feeding value in the order named, though with slight differences in any case. So that, what hereinafter is said of red clover, and its feeding value will apply much the same to alsike and alfalfa. During the last winter season, comparative results were obtained from the fattening of lambs on clover alone, with those receiving both clover and grain. These results have been so satisfactory, both by way of quantity and quality of product and financial return, that as the harvest season of 1900 closes, with innumerable clover stacks dotting the valley, we feel that the results of our work may at least offer some suggestions regarding the use of clover in mutton production.

On December 12th, 1899, 60 lambs were started on a 90 day feeding test. These were divided into three lots of 20 each; lot (1) received clover and wheat, lot (2) clover only, and lot (3) clover and oats. Within this period of 90 days, the lambs feeding on clover alone, consumed an average amount of 3.16 pounds per head, per day. The two lots receiving an average of .93 pounds wheat and oats respectively per head each day, consumed only 2.14 pounds clover.

The gains made during the 90 days were as follows: Lot (1), fed clover and wheat, 30 pounds each; lot (2), clover only, 24.3 pounds; lot (3), clover and oats, 31.75 pounds each. Considering

the fact that nearly a pound of grain was fed to each lamb, per day, to two of the lots, the showing made by clover alone is remarkably good. With lambs of the range type, feeders seldom reach a gain of ten pounds per head, per month, when both hay and grain are used. The two lots receiving grain and clover also had a slight advantage from the use of a small allowance of roots.

Cost of Feeding.—The clover hay was charged up at $6.00 per ton, damaged wheat at 40 cents per cwt., and oats at 90 cents per cwt. At this rate the cost of food for each of the three pens of 20 each, for 90 days, was as follows: Lot (1), clover and wheat, $19.38; lot (2), clover only, $17.21; lot (3), clover and oats, $27.95. The total gains per ton, in order, above given, were: Lot (1), 601 pounds; lot (2), 486 pounds; and lot (3), 635 pounds. Considering these gains, and the cost of foods, the clover and wheat ration produced mutton at a cost of $3.22 per cwt. increase, clover alone $3.54, and the clover and oats $4.30. These results show conclusively that, though clover alone did not give absolutely the most rapid or cheapest increase, still, there was little difference between it and the clover and wheat ration, and that satisfactory gains and financial returns can be obtained from the clover alone. They also show that oats at the price charged, cannot be profitably used except in small quantities.

The profits derived from these three methods of feeding, at the end of 90 days, were:

Net profit per head, from lambs fed clover	and wheat..	96 cts.
" " " " " " " "	only.........	82 "
" " " " " " " "	and oats..............	62 "

The lambs were bought at $3.00 each and sold at the rate of $4.68 per cwt., live weight. We conclude from the results of No. 1, that cheap grains, otherwise unsalable, can be used to good advantage along with clover for fattening lambs, and also, that while the clover alone gave good results, we believe that where possible a small amount of grain fed with it, will increase the gain and add to the quality, but large quantities are not necessary with the quality of clover here produced. From the data obtained it was found that 11.8 pounds of clover was required to maintain the animal and produce a pound of gain. Thus one ton of clover produced 169.5 pounds of mutton, which, at the selling price of

$4.68 per cwt. was worth $7.93. Is this not a good market value for one ton of clover hay? Is it possible to dispose of it to better advantage in any other way?

The necessity of securing the proper type of lambs for feeding is very important. During the past two seasons, comparative results have been secured by feeding lambs of the mutton type, and wool producing kind by similar methods. Those of the mutton type used, contained a large percentage of Shropshire blood. They were large framed and strong boned, cylindrical of form, possessing broad evenly fleshed backs, with good width at brisket, chest, and shoulders. The other class, composed of Merino grades, were almost the reverse as to general form and quality. The compact lamb, of the former class, carrying a large quantity of natural flesh, when fed on an expensive ration of clover and oats, produced 100 pounds gain at a cost of $4.39 per cwt., while those of the inferior type, using the same kind of food, in the same amount, cost $4.65 per cwt. increase. The lambs of the mutton type required over one-half pound less clover to each pound of increase.

The results obtained lead us to conclude that, with the conditions which Gallatin valley presents, the possibilities for mutton production are unparalleled, for in the first place, the best foods can be grown abundantly, and secondly, we have the stock near at hand to consume it. Individual acres of clover, grown at the Experiment Station, for three successive years produced over one and one-half tons of hay, at from 119 to 133 days from date of sowing.

During the season just closed, a field of 7.26 acres produced, at two cuttings, a total of 35 tons 1,451 pounds of well cured clover hay. And while this food can be produced in such great abundance, it has the advantage of possessing a large percentage of those nitrogenous compounds or flesh formers which the eastern feeder, who relies chiefly on corn or screenings, cannot buy. The clover produces a much better quality of meat than the starchy foods, such as screenings, corn, barley, etc., and this will apply to beef and dairy productions as well.

While the production of clover, and its conversion into mutton is desirable, this need not interfere with the grain output. On the contrary, clover must materially assist the grain producer, taking

the place, as it is, of the vast summer fallow area. We therefore have the clover for feeding purposes without decreasing the grain area.

The question of the disposal of finished mutton is one which confronts us in a serious way, as the local demand does not require but a limited quantity. It is the purpose of the Experiment Station to fatten a car load each of lambs and steers, for shipment to Chicago in the early spring. Several others have also signified their intention of feeding in time to join this experimental shipment. We have found that it will pay to feed lambs from 70 to 90 days and steers at least 120.

Results justify conclusions to the effect that mutton can be successfully produced on clover alone, though the use of a small grain allowance is desirable especially because of its ultimate effect on quality. Where clover or alfalfa may have been damaged and unsaleable, it cannot be used in a better way than as a sheep food. We cannot urge too strongly the growth of clover in Gallatin valley and its subsequent conversion into mutton.

What has been said of the clover and Gallatin valley conditions, will apply in much the same way to the numerous alfalfa regions of Montana.

CHEMICAL DEPARTMENT.

F. W. TRAPHAGEN, Chemist.

The usual lines of work have been carried on by this department during the past twelve months. A considerable amount of time was given to an examination of the condition of the foods found in our market and a resume of the results is introduced here. A detailed report of this work has been published in the Biennial Report of the Bureau of Agriculture, Labor and Industry.

Much interest has been manifested in this work and numerous newspaper articles have been written, and addresses given in an effort to better conditions by arousing public sentiment and securing the enactment of proper legislation for the protection of our citizens. Through the efforts of Senator Hoffman a bill was introduced into the legislature at its last session and its passage through the Senate secured. The activity of a lobby of grocers, mainly from Butte, caused the defeat of the bill in the House of Representatives, not, however, without the disapproval of a large number of our best citizens.

It is to be hoped that funds will be found for the purchase of another series of samples to be used as an object lesson in another campaign for protection.

RESULTS OF FOOD EXAMINATION.

	Found Adulterated.	Not Found Adulterated.
Canned Vegetables	6	25
Soups	5	9
Tomato Catsups	12	0
Jams, Jellies and Preserves	26	0
Cereal Breakfast Foods	0	30
Baking Powders	9	6
Flour	0	18
Miscellaneous Foods	15	13
Vinegars	21	6

The sugar beet investigations of the past season have not been at all satisfactory. Because of changes in the administration of this part of our work, seed was not sent out sufficiently early to secure active co-operation on the part of our farmers and very few reported having planted.

This season we have projected the most general test yet carried on, and every agricultural section of the State will be represented in the trials. The seed has been sent out sufficiently early to secure the benefit of planting as soon as conditions permit and the results should be of considerable value.

On the Bitter Root Stock Farm, near Hamilton, Mont., the most systematic series of experiments, yet made within the State, are being carried on. Small tracts selected at different points on the farm have been chosen, affording a great variety of soil and conditions. Sugar beets are being grown on these plats under the direction of a skilled sugar beet culturist from Utah, and will be handled far better than they ever have been in this State. Heretofore the crop has been grown incidentally, usually merely as a favor to the Experiment Station, and has received attention when everything else has been looked after. While we greatly appreciate the assistance we have received from co-operating farmers, it is no less true that sugar beets have been greatly neglected in the past and the excellent results previously obtained have been in spite of very unfavorable conditions.

Besides the tests above mentioned, through the efforts of Hon. W. A. Clark, seed has been widely distributed throughout the valley of Clark's Fork of the Yellowstone river, and a new field will be studied here. There is little doubt that, if the results of the present season are satisfactory, a beet sugar factory will be established at some point within the State. This means much, not only to the favored community, but to the State at large.

In connection with our study of the alkali problem we have been making a series of experiments to determine the limit of tolerance for alkali of our different crops. These tests have been very satisfactory and serve to show that there are very few places in our State where the alkali alone is in sufficient quantity to prohibit the growth of our usual crops. A number of interesting points have been noted in this investigation, which will be pre-

sented in a bulletin soon to be issued. Successive series of experiments have been planned with various plants, which, taken in connection with our analysis of the soil of different sections, will enable us to prescribe the crop most likely to succeed in any instance.

Pot experiments have been instituted to determine the best methods of handling such soils as resist ordinary methods of treatment. The effects of tailings and tailings waters from the copper smelters, upon hay and grain crops, have been carefully studied and the results will be embodied in a bulletin to be issued soon. It may be said that the conclusion was reached that chemically there has no evil resulted from the presence of metals in solution and that the mechanical effects are the same as would come from the presence of the same amount of sand or clay under similar conditions.

A resume of the analytical work shows the following as the work of the year:

Soils	285
Foods	201
Water	10
Milk, etc	4
Butter	12
Beets	7
Coal	8
Miscellaneous	36
Total	563

BOTANICAL DEPARTMENT.

J. W. BLANKINSHIP, Botanist.

The work of the botanist during the past year has been confined chiefly to a study of the weeds of the State and the preparation of a summary of our knowledge of the same, issued as Bulletin No. 30 of this Station, and a continuation of the study of the plants poisonous to stock and the conditions under which that poisoning usually occurs. Unfortunately the field work could not begin until June 1, after the main period of poisoning was over, so that relatively few cases could be investigated immediately after the poisoning occurred. Nevertheless, through the co-operation of the various railways traversing the State, a large amount of data was accumulated and the distribution of the plants chiefly concerned was largely determined.

In addition to this work a considerable number of plants sent in for identification have been determined and more than a thousand specimens have been added to the herbarium, among which was a set of the grasses of the United States from the Division of Agrostology at Washington.

A NATIVE HEDGE PLANT.

Hedges are desirable in every country not only for their permanent utility in fencing yards and fields, but also for their ornamental value. As yet no plant has come into general use in Montana for this purpose, but a series of independent experiments

have been made in various parts of the State to utilize the buffalo-berry shrub (*Shepherdia argentea, Nutt.*) for this purpose, and, while not fully successful, the results seem to show that with proper care the plant can probably be made to answer the purpose.

Shepherdia argentea, Nutt. grows in the lowlands along streams throughout the Great Plains region from Manitoba and Kansas westward to the mountains and in the Great Basin to the Sierra Nevada range. In Montana it is found in more or less abundance east of the Divide, along the Missouri, Yellowstone and their tributaries, often forming dense impenetrable thickets in the lowlands. It is a shrub, or small tree, rarely exceeding 25 feet in height and a diameter of 5 or 6 inches, with widely spreading, tough and thorny branches and bearing a dense cluster of pale red, rarely yellow, berries, ripening in autumn and having a sharp acid flavor, esteemed for jelly-making, for which they are extensively used.

Although the plants grow naturally only in the low ground, there is no reason why they should not be made to grow wherever the roots can be kept moist by irrigation in the plains or valleys in any part of the State. The following gentlemen give the results of their experiments with the buffalo-berry plant for the benefit of others who may care to continue the work.

Mr. John Matheson, living 8 miles east of Chinook in the Milk river valley, writes (December 21, 1900) as follows:

"The buffalo-bush hedge was planted three years ago as an experiment and seems to answer the purpose. It grows in alkali land, stands the climate and bears trimming. It is not a very fast grower and it will take about 6 years before it can be depended on for a fence. I tried to grow the plants from the seed, but failed, owing to the place being flooded in the spring. The plants should be reset, when not more than six inches high, in a double row about twelve inches apart each way. The cost of such a fence will not exceed 50 cents a rod. The Osage orange will not grow; I tried it and failed."

Mr. Olney Taylor, of the State Board of Horticulture, has performed a similar experiment at Park City on the Yellowstone and gives his conclusions (November 12, 1901) as below:

"In regard to the buffalo-berry as a hedge plant I will say that my experience with it is rather limited. A few years ago I planted some seeds along the road, which grew well and, if they had been properly pruned, I think would have made a good hedge, but they have been allowed to grow naturally and are tall and not as thick as they should be. The greatest objection I have to them is that they sprout quite badly where the ground is cultivated near them."

Mr. A. M. Crawford, of Billings, is another who has tried the plant for this purpose and writes under date of November 13, 1901:

"The buffalo-berry makes a beautiful and effective hedge. The land should be in good tillable condition before planting. If new ground, a strip about four furrows wide and two furrows deep—as deep as the plow can be made to run—should be prepared in the fall for early spring planting. While the buffalo-berry is native along our river bottoms, I find that the young plants can be readily established on uplands, but with difficulty on low, soggy ground; and that, while in the former position they must be carefully irrigated, in the latter they are likely to get in a way troublesome brush. One more weaving and you have a hedge that cattle, and even boys, are willing to let alone. From this time on it is a question of neatness and the pruning shears. The work of weaving can be greatly facilitated by having smooth wires at stated intervals under which to bend the young wood."

The buffalo-berry will not grow in the foothills above 3,000 feet altitude, but it may be possible to utilize the black and red haw (*Cratægus coccinea*, *L.* and *C. Douglasii*, *Lindl.*), which take its place in those situations and grow in abundance. For ornamental hedges the barberry (*Berberis Canadensis*, *Push* and *B. vulgaris*, *L.*) and the privet (*Ligustrum vulgare*, *L.*) may well be employed as they are perfectly hardy in most situations below 5,000 feet and have been grown successfully in the gardens of the Station at almost that altitude.

THE "ARCTIC BERRY" FRAUD.

For a number of years a man, with a camping outfit, has been canvassing various parts of the State selling a so-called "Arctic berry," taking orders throughout a particular section during the spring and summer and delivering the plants in the fall. He exhibits a number of the "berries" preserved in a liquid in a bottle and they are said to have a very attractive appearance, being "three times the size of a strawberry and with the color of an orange." He claims the fruit is of his own production, resulting from crosses between a number of berries of which the huckleberry, sarvice berry, strawberry, wild cherry and several other unnamed species, play a part, the whole combining to form the wonderful fruit then exhibited. He claims the fruit was first grown by himself in Idaho, and is now cultivated successfully in the Gallatin valley, near Bozeman. From reports it seems that this plausible gentleman has "worked" a great part of the State, including the region about Great Falls, the Gallatin valley and the Madison river and spent the summer of 1901 in Sweet Grass and Carbon counties. The matter was called to the attention of the Station in time to advertise the fraud in the newspapers before the delivery of the "berries" and relatively few were disposed of. It was then stated that any man knowingly making such statements as those attributed to him in regard to the origin of the fruit in question, was a fraud and subject to prosecution under the laws of the State, and he was asked to submit some of the fruit and plants to this Station that we might pass upon the value of this remarkable hybrid. Notice was also given in all the Bozeman papers for information in regard to this new plant, from anyone cultivating it in this vicinity, but no responses have been received either from the agent or from any successful grower, for all the plants sold in this vicinity are either dead or killed down each year by the frost, and we have yet been unable to secure living specimens for examination. Horticulturists, who have seen the growing "Arctic berry," report the plant sold as the white mulberry (*Morus alba, L.*) and some leaf-scraps examined seem to agree with that species. The thing is a palpable fake, for such crosses as those mentioned

are botanically impossible. Space is here given the subject in order to protect the people of the State from such imposition hereafter, and to warn our neighbors of adjoining States to look out for this smooth-tongued "nurseryman."

POSSIBILITIES OF STRAWBERRY CULTURE IN THE STATE.

In a state with great variations in climate, due to the difference in altitude found in mountainous regions, it is possible to extend the fruiting period of seasonal fruits, such as the strawberry, over considerable time by taking advantage of this progress of season at the different altitudes, and this fruiting period may be still further extended by planting early and late varieties. As far as can be yet judged by the native vegetation, there appears to be a difference of about a week in the opening of flowers and the ripening of fruit for each 2,000 feet of altitude and as our altitude ranges from about 1,800 to over 11,000 feet, it seems that advantage might be profitably taken of this fact for growing a fruit for which there is always a ready market.

THE ALKALI DISEASE OF PLANTS.

Several times recently my attention has been called to a supposed parasitic disease affecting plants in certain localities, but upon examination no fungus was found, but the plants had every indication of poisoning by alkali, either through the rise and settling in low ground of the waters of irrigation containing these salts in excess, or through watering potted plants with such water. In general, plants thus affected show it by the gradual yellowing of the foliage, or by the withering of the leaves at tips and edges, until they die and drop off, causing the death of the plant. A considerable number of the trees in the park along the river side, at Great Falls, appear to have died from this cause and the same trouble has been found with shade trees in certain localities at Helena and Bozeman. The remedy in such cases is clearly

underground drainage to carry off the excess of salts accumulating in the water in such situations, or a reduction in the irrigation on the higher ground near by. The trouble seems also to affect potted plants and gardens, when watered with water containing an excess of alkali, and cases have arisen seemingly from this cause at Columbia Falls and Helena and will doubtless be noted from other localities in the eastern part of the State, the remedy here being to secure water from some source not thus contaminated.

The effects of alkali upon plants are thus described by Dr. E. W. Hilgard, director of the California Experiment Station: "In the case of herbaceous plants the first effect is a dwarfing of the whole system, and as the salts accumulate at the surface, they will cause a corrosion of the root-crown. In the case of trees also the root-crown usually shows a darkening of the bark, and a browning of the liber, if the alkali is strong enough. It is then that the leaves yellow, but short of such an effect upon the root-crown the essential symptom of alkalied plants is a dwarfing."

INVESTIGATIONS OF PLANTS POISONOUS TO STOCK IN MONTANA.

This work, begun during the preceding summer has been continued for most of the present season, but has been confined mainly to field work to determine the plants causing the various cases of poisoning reported, the times of the year when such poisoning is most apt to occur with the conditions then prevailing and the localities in the State found to be most dangerous to stock, with the reasons therefor; also, to determine the distribution over the State of the plants known or suspected of causing this poisoning and to devise methods for avoiding the same, as far as possible. The work of experimentation to ascertain the exact effects of suspected plants upon animals has been left, by agreement, to the specialists of the Department of Agriculture, who are conducting their work at this Station during the present summer.

In order to call the attention of stockmen to this work and secure their assistance in conducting the same, the following circular was issued:

NOTICE TO STOCKMEN.

The Montana Agricultural Experiment Station in co-operation with the Department of Agriculture at Washington and the State Veterinarian at Helena, is attempting during the present season to make a study of the plants poisonous to stock in this state. In order to fully determine the conditions under which the poisoning normally occurs and the plants to which it may be referred, it is desired that detailed reports be made to this Station of losses now occurring, as well as any losses which may have occurred in the past, noting, as far as practicable, (1) the exact locality in the State in which such poisoning occurred and the local conditions, whether lowland or upland, plains, foothills or mountains, about springs or along streams; (2) the time of the year of such poisoning; (3) stock affected, whether horses, cattle or sheep; (4) the number poisoned, their symptoms and treatment pursued, as well as relative proportion of deaths; and (5) the plants suspected, with descriptions or specimens. It is only by the compilation of such data that the dangerous zones in the State can be accurately determined, as well as the time when they must be avoided.

By the co-operation of the stockmen of the State in this work, particularly in reporting promptly for investigation, all new cases of poisoning that may occur, it is hoped that definite results may be secured and the present loss due to this cause prevented.

Address all communications and specimens to, MONTANA AGRICULTURAL EXPERIMENT STATION, Bozeman, Montana.

June 5, 1901.

The results of this investigation will be issued as a bulletin early next spring in time to be of service to the stockmen during the dangerous season.

In order to make this work as practical as possible, the Station has had sets of the plants, suspected or known to be poisonous, mounted and framed for general distribution in the principal stock-growing centers and these will be sent to anyone who will pay the expense of framing and transportation and agree to place them on exhibition in some public place in his locality. A number of these frames have already been distributed. It is hoped that next season portfolios can be prepared of the most dangerous species for distribution to stockmen to be placed in the hands of their foremen and herders to make known the plants, which must be avoided or destroyed, but at present not enough specimens have been collected to enable this to be done, except in a few cases.

ENTOMOLOGICAL DEPARTMENT.

R. A. COOLEY, Entomologist.

An account of five insect pests, not previously mentioned in the publications of this Experiment Station as being present in Montana, is herewith presented. All are of first-class importance, some having proved themselves very injurious to our vegetation and the others being well known for their destructive habits elsewhere.

The year's experience has emphasized the importance of the entomologist's being about the State as much as possible in order that the presence of injurious insects may be detected and made known. The widespread belief in Montana that injurious insects have not yet found their way to our fields is only partially based on facts, but is due, rather, to a lack of knowledge of the real conditions. It seems clear, then, that the actual conditions should be published as rapidly as possible so that the fruit grower and rancher may not, through ignorance of their presence, allow them to gain a foothold. The past year has developed a knowledge of the presence and distribution of a considerable number of very important pests and there can be no doubt that the coming year will reveal many more.

with gray, white, black and brown markings. Three diamond shaped spots on the back of this long, slender and shy moth make it easily recognized.

Spraying the affected plants with water is said to be a good remedy. The insect thrives only in dry weather. Pyrethrum insect powder has given satisfactory results. The larvae often co-exist with the cabbage aphis, discussed below, and are readily destroyed by the substances used in controlling that pest.

THE CABBAGE APHIS.

Aphis brassicae. Linn.

A great many fields of cabbage and related plants were wholly or partly destroyed during the year by this species and a large number of letters concerning it were received and answered. The insects were present in almost incredible numbers completely covering all parts of the plants and working into the heads of cauliflower in such numbers as to destroy their value. Affected plants withered and appeared as if suffering from dry weather.

The real color of the lice is greenish gray, but this is obscured by the waxy or mealy secretion which covers their bodies and gives them a leaden color.

The species attacks cabbage, turnip, cauliflower, rape and other plants of the same natural family (*Cruciferae*).

As a remedy for the pest, kerosene emulsion, one part of the emulsion in ten of water, or whale-oil (more correctly fish-oil) soap one pound in fourteen gallons of water, may be used.

The insects readily succumb to these substances, the only difficulty in the treatment being to get the insecticide in contact with all the lice.

The lice cover both surfaces of the leaves thereby making it necessary to spray the under as well as the upper surface. The spray-nozzle must be lowered among and under the leaves. It may, if desired, be fastened to the end of a piece of half-inch tubing which will allow the operator to stand erect.

THE ROSE CURCULIO.

Rhynchites bicolor. Fab.

This insect is generally distributed throughout the United States and while having been seen by the writer only at Bozeman, Missoula, Hamilton and Kalispell, in Montana, it is almost certain that it occurs in all parts of the State.

The rose curculio is a beetle one-fourth of an inch long, red over the entire upper surface from the head to the tip of the abdomen, with the ventral surface, beak or snout, antennæ and legs black.

It affects both wild and cultivated roses, boring by means of its long snout into the buds and cutting the stems causing the buds to lop. It is particularly destructive west of the range where roses are grown more readily than on the east side.

Great injury to roses is caused by this species. It takes very much the same place that the rose chafer (*Macrodactylus subspinosus*) occupies in the east.

No very satisfactory remedy is known. The writer is making observations on the habits of the species and hopes to find some means of defense against it.

Temporary relief may be secured by hand picking or by drumming them off into a pan of kerosene, or kerosene and water.

SUB-DEPARTMENT OF POULTRY.

H. C. GARDINER.

Student in Charge.

During September, October, November and December 1900 three pens of fowl were fed separately, with a view to determine the best method of feeding and caring for hens during the moulting period. While this work was not carried far enough for conclusive results, we would from the results obtained, advise a liberal ration for moulting hens, and attention early in the fall. It was found that flax seed was a valuable addition to the ration, and that a full ration tended to stimulate the growth of feathers.

Although we must depend chiefly upon early hatched pullets for winter eggs, still it is an additional source of profit if the year old and two year old hens can be made to contribute their share to the egg-basket. In order to secure these results fowls must be fed liberally commencing in September, in order to hasten the moulting of those who have begun, and to start those whose low condition, resulting either from rearing a brood of chicks, or laying late in the summer, has left them without vigor enough to moult before cold weather. Owing to this general low condition which follows the summer's work the flock may not respond readily to their feed, and it is advisable to stimulate and tone the digestive system with Cayenne pepper, assafoetida, etc., and give "Douglas mixture" in their drinking water twice a week. Douglas mixture consists of four ounces copperas, one ounce sulphuric acid in two gallons of water, using it in the proportion of a tablespoon in a quart of drinking water twice a week. Such precautions will to a great extent fortify the bird's system against roup and colds which occur so generally in this State in the fall and winter months.

During the past year we have received many inquiries about how to treat flocks which are affected with roup and colds, and we have advised maintaining all stock in a vigorous condition in order that they may successfully withstand our broken fall and

winter weather. Debilitated animals are the most susceptible to diseases of any kind, and improper quarters and poor feed only add to the danger. In order to secure freedom from roup the houses must be dry, free from draft, of reasonably even temperature and well ventilated. Frame houses are best because they are easily kept dry, and we believe that it is a mistake to construct poultry houses of stone or concrete, as the walls of such buildings are almost invariably damp, and fowls kept in such buildings are particularly liable to disease. In order to maintain an even temperature all chinks and cracks should be kept closed and the building made as tight as possible, with a window space of about one-eighth of the front in a building six feet high. Too large an area of glass causes the building to heat very quickly during the middle of the day, while at night it affords a large radiating surface, chilling the interior and producing catarrh and colds among the inmates. This difficulty may be overcome best, by the proper glass area, and by the use of a stove on cold nights and during long cloudy spells. Last, but not least, comes the ventilation question, while a building should be built as nearly air tight as possible, it should also be well ventilated. Nothing poisons the animal system more quickly than impure air laden with gases exhaled by the fowl, and arising from the droppings. These gases being naturally heavier than the air settle in the lower portions of the house, and it is from these lower levels we must ventilate. Ventilators opening at the roof are inefficient; while they may remove a portion of the lower body of air, they remove chiefly the upper portion which is warm and pure and which should be retained. To thoroughly, cheaply and easily ventilate, run a common six-inch stove pipe from the roof to within six inches of the floor, having a damper in it at a convenient height. The warm air near the roof warms this pipe, which in turn warms the air inside, and this enclosed air rising creates a draft which gradually and successfully removes the impure air in the vicinity of the fowl. We believe if the many inquirers and others, whose flocks are affected, would follow these directions, this disease which is so prevalent throughout the State would soon become checked.

During January, February and March another feeding experiment was conducted in which six pens, comprising 90 birds in all,

were fed to determine the feeding value of three of our most widely grown grains, wheat, oats and barley, and further what advantage is to be gained from mixed grain rations. Although this work will be continued further before any definite conclusions are drawn we believe that oats and wheat is the most profitable mixture and wheat is the most desirable to feed alone.

The department also published a bulletin designed to meet the needs of beginners in this branch of farming, which discussed the following topics: Breeds of poultry best suited to Montana's market and climatic conditions, artificial incubation and the care of incubator chicks, general management of breeding stock and laying birds, advantages of pure-bred stock, construction and ventilation of buildings, construction of brooders and brood coops, incubator oils, and egg-preservation. The results of feeding experiments which were planned to show the necessity of variety rations in egg production were also given, together with data relative to the effect of these different rations upon egg fertility, and upon the composition of the egg.

During the winter months we were forced to keep several of the pens confined on account of lack of yards, the ground about the building being only partially graded. We found as a result of this confinment that even with careful precautions the vice of egg eating developed to a very considerable extent among the hens, and cutting the beaks was only a temporary check. Darkening the nesting place also had no effect, and at a loss to stop the practice by any specific means, we dug post-holes in the frozen ground with giant powder and erected temporary fences. This proved an effectual remedy, for as soon as the birds secured the run of the yards the practice ceased with the exception of one or two individual cases. This practice is evidently the immediate result of idleness resulting from close confinement and is best remedied by removing the cause of the evil.

The spring months were devoted almost exclusively to raising pure-bred chicks, and with the stock raised this year we have been able to replace all the old mongrel stock and culls, and now have for the first time all our pens filled with first-class breeding stock which adds much to the value and attractiveness of the department.

Numerous enquiries are received from time to time with reference to construction of buildings, feed of fowl, diseases, incubators, etc., all of which are answered as required.

HORTICULTUTAL DEPARTMENT.

CHARLES WILSON, Gardiner.
Temporarily in Charge.

ORNAMENTAL SHRUB CULTURE.

In all fifty deciduous shrubs have been tested for four consecutive years. This year's work has confirmed the results of the three preceding years. Twelve varieties have been found to be hardy, nineteen semi-hardy and nineteen worthless.

HARDY.

Berberis Canadensis, American Barberry.*
Berberis Vulgaris, European Barberry.*
Berberis Vulgaris purpurea, Purple-leaved Barberry.*
Cornus Sanguinea, Crimson Dogwood.*
Legustrum, White-berried Privet.*
Ribes aureum, Yellow-flowering Currant.
Symphoricarpus racemosus, White Snowberry.*
Syringa Caerulea Superba, Lilac.
Syringa Villosa.
Syringa Vulgaris, Louis Spath.
Syringa Vulgaris, Princess Alexandria.
Viburnum opulus Sterilis, Snowball.

*Those starred have had young wood slightly winter killed two or three seasons, but not sufficiently to interfere seriously with the progress of the shrub. The balance do not suffer in the least from the severity of winter weather and will probably give good results throughout the State where the altitude does not exceed 5,000 feet.

SEMI-HARDY.

Berberis Aquifolia, Mahonia.*
Elaeagnus longipes, Silver Thorn.*
Hydrangia paniculata grandiflora.*
Lonicera Tartarica grandiflora, Pink-flowering Honeysuckle.*
Lonicera Tartarica alba, White-flowering Honeysuckle.*
Prunus triloba, Double-flowering Plum.
Pyrus Japonica, Japan Quince, Scarlet.*
Pyrus Japonica, Japan Quince, Blush.*
Rhus glabra laciniata, Cut-leaved Sumac.*
Sambucus nigra aurea, Golden-leaved Elder.*
Spiraea Van Houttei.
Syringa, Garland.*
Syringa, Golden.
Syringa, Large-flowering.
Tamarix.
Viburnum.
Syringa rothomagensis.
Saulbucus nigra laciniata, Cut-leaved Elder.*

*Young wood half kills back each winter. While this occurs under our local conditions there are more suitable localities in the State where these will answer well. Those not starred in this group do well here.

SHADE TREES.

The Russian and Carolina poplars have given the best results being particularly hardy. The former is a fast grower, branching and symmetrical with large leaves. The yellow cottonwood follows these two closely.

Box elders, raised from seed, are hardy and growthy, but this does not seem to be the case with imported stocks.

Mountain ash has proved to be hardy and a rapid grower of good shape.

The ash, elm, English elder, maple and burr oak have proved to be worthless unless under very favorable conditions.

ROSES AND FLOWERS.

Of the 28 kinds tried only two are hardy so that they can be grown without covering. These are the Persian yellow and Magna Charta. The former produces a great profusion of large yellow roses.

In the green houses 30 varieties of chrysanthemums and 20 of carnations have been propagated. These lend much attractivenes to the place and are a source of income as there is a great demand for them.

EXPERIMENTS IN FRUIT CULTURE.

APPLES.

The varieties given below have been set in the orchard most of them six years, and the balance four and five. The relative hardiness of these has now become a certainty and much more has been learned this year regarding their bearing capabilities and the quality of the fruit.

HARDY.

Anisette	Langfield
Bogdanoff	Number Twelve
Ben Davis	Orel
Duchess of Oldenburg	Okabena
Gano	Royal Table
Gipsey Girl	Thompson's No. 10
Good Peasant	Voronesh
Gideon	Wealthy
Hibernal	Yellow Transparent
Lead 3 N	Zuzoff

These kinds have all came into bearing with good results except for Orel, the fruit of which fell before maturity.

NOTES ON FRUIT.

Longfield.—Good yielder, medium size, medium early fall apple.

Wealthy.—Late fall or winter, big yielder, attractive fruit.

Gideon.—Late, large and attractive.

Hirbernal.—Good yielder of large greenish red fruit; winter.

CRABS.

Bailey's Crimson	Pride of Minneapolis
Florence	Russet
Greenwood	Transcendant
Hyslop	Whitney No. 20
Martha	White Arctic
Orange	

All these are now in bearing and may be classed as hardy except for Whitney and Orange.

Of these ***Transcendant*** was one of the most satisfactory, being early and yielding a large quantity of medium sized fruit.

Whitney.—Also produced well but is a little tender.

Russet.—Ripened early, fruit sweet and pear shaped.

Hyslop.—Has been a continuous bearer for three years, large quantity of medium sized fruit, but a little late.

Bailey's Crimson.—Good yielder, early and medium size.

Martha.—Good size, medium early.

Pride of Minneapolis.—Small, green, sweetish, medium early.

Orange.—Late and semi-hardy.

PLUMS.

Of the many varieties tried, but one, the Moldorka, has succeeded in ripening fruit. Two trees of the same age came into bearing, producing 30 pounds of large blueish fruit which ripened by September 10th.

STRAWBERRIES.

Of the large number tried in the original tests only five are recommended, viz.: Splendid, Bisel, Ivanhoe, Crescent and Bederwood. Of the 37 varieties of more recent introduction only two have been selected, the Wolverton and William Belt.

RASPBERRIES.

The Marlborough, Hausel and Brandywine, only, have given good results under the local conditions. The former freezes back slightly, but yields well. The two latter are the hardiest and are good yielders of good quality.

Though the Clark and Gurner freeze back they produce moderately well, but the berries are soft and of little account.

Columbian, Early King and Cuthbert have been tried, but freeze down every winter.

IRRIGATION DEPARTMENT.

S. Fortier, Irrigation Engineer.

ONE SOURCE OF WASTE IN IRRIGATION.

In Montana, water for irrigation is conveyed for the most part through channels in earth. Ordinary earth is porous and will not retain water without considerable loss. When large volumes are carried in open canals over long distances the loss or waste of water from this one cause frequently exceeds one-fourth of the total flow. The percentage of loss varies in accordance with the physical conditions. In retentive clay soils the seepage loss is usually small. On the other hand when canals are located around foothills and over sandy and gravelly benches the loss is usually great.

In the absence of accurate measurements the loss in conveyance was not known. Irrigators were aware that much less water was available at their respective headgates than entered the main canal, but they attributed the deficiency largely to evaporation and absorption along the route. The water that seeped from the bottom of the canal could not be seen by the ditch rider and its effects were not always apparent on the land bordering the canal. The joint efforts of this Station and the Department of Agriculture in making a series of measurements on each of several typical canals in the State and publishing the results have directed general attention to the subject of the seepage loss from canals.

For two seasons the loss due to seepage on several of the large canals of the State has been ascertained. The following table gives in brief the principal results:

Date.	Total Flow at Head. Sec.-Ft.	Distance in Miles.	Loss in Sec.-Ft.	Percentage of total Supply Lost.
Middle Creek Canal, Gallatin County.				
June 10, 1899	98.9	4	21.5	21.7
" 27, 1900	63	4	12.2	19.4
Farmers' Canal, Gallatin County.				
July 30, 1900	133.1	10¾	23.59	17.71
West Gallatin Irrigation Canal, Gallatin County.				
July 18, 1900	114.45	38¾	38.93	34
The Big Ditch, Yellowstone County.				
August 9-13, 1900	254.47	22	65.05	25.55
The Republican Canal, Ravalli County.				
July 21-24, 1900	120.49	12 1-5	38.84	31.32

AN EQUITABLE DIVISION UNDER CO-OPERATIVE CANALS.

While enormous yields can be produced under irrigation the system is not without its drawbacks. One of these is the difficulty encountered in dividing water equitably among a large number of shareholders. In average years water is fairly abundant in this State, but owing to a light snowfall for two winters in succession the water supply has been deficient in many sections. The difficulty has been aggravated in not having proper headgates and measuring boxes. The division of water is usually based on the wild guesses of the water master.

So long also as the loss in conveyance was not even approximately known it was impossible to give each user his proper share. The irrigation department of the Experiment Station has begun a good work in determining for the canal owners the percentage of loss in their canals and devising suitable methods by which the flow through each farmer's headgate may be controlled and measured. Measuring devices, including both weirs and rating flumes, have been built under the supervision of the Station officers in different cultivated valleys of the State for the purpose of introducing more modern methods.

THE USE OF WATER IN IRRIGATION.

For the past two seasons experiments have been carried on by this Station in co-operation with the Office of Experiment Stations at Washington, D. C., to ascertain the actual quantities of water used in irrigation. Without this knowledge it would be impossible to reach any definite conclusions as to the agricultural possibilities of any irrigable tract of land. One might know the amount of the available water supply and the extent of the land to be irrigated, but if he did not know the average amount of water that should be applied per acre, the number of acres that might be reclaimed by the flow of a stream could not be determined.

In like manner, when a storage reservoir is to be built it is important to know, before the enterprise is begun, how much land a given quantity of water will irrigate. It is comparatively easy to obtain the capacity of the reservoir before any construction work is done, but if no tests have been made in the vicinity on the amount of water required per acre the area which the stored water will irrigate can only be roughly estimated.

Then, too, one of the first steps necessary in defining a water right is to ascertain the amount of water economically used. One of the greatest difficulties experienced by the courts in settling water rights is the lack of knowledge on this particular subject. The following table contains a brief summary of the more important investigations on the use of water in irrigation:

Duty of Water in 1899.

Kind of Crop.	Name of County.	Area Irrigated Acres.	Depth of Water.			Water* Applied per Acre. Tons.	No of Irrigations.	Yield per Acre.
			Irrigation.	Rain.	Total.			
Red Clover	Gallatin	27.44	1.02	.44	1.46	1386.8	2	3.0 tons.
Peas	do	4.23	1.10	.41	1.51	1495.6	2	31.25 bu.
Barley	do	5.25	1.98	.42	2.40	2692.05	2	45.00 bu.
Wheet	do	6.02	1.98	.42	2.40	2692.05	2	57.89 bu.
Barley	do	66.39	.98	.41	1.39	1332.4	1	....
Oats	do	23.41	1.53	.38	1.91	2080.2	1	51.00 bu.
do	do	7.26	1.34	.36	1.70	1821.9	2	72.75 bu.
do	do	2.48	2.16	.36	2.52	2936.8	2	72.75 bu.
do	do	25.09	1.28	.44	1.72	1740.3	1	....

* Not including Rainfall.

Duty of Water in 1900.

Kind of Crop.	Name of County.	Area Irrigated Acres.	Depth of Water.			Water Applied per Acre. Tons.†	No. of Irrigations.	Yield per Acre.
			Irrigation Ft.	Rain Ft.	Total Ft.			
Red Clover.	Gallatin	66.39	1.98	.44	2.42	3290.3	2	....
Barley	do	4.14	1.50	.28	1.78	2420.2	2	46.5 bu.
Oats........	do	25.09	.64	.39	1.03	1400.4	2*	....
Wheat	do	1.00	.77	.30	1.07	1454.8	2	38.33 bu.
Red Clover.	do	1.00	.77	.30	1.07	1454.8	2	1.58 tons.
Oats........	do	1.00	.56	.39	.95	1291.6	2	75.58 bu.
Peas........	do	1.00	.56	.39	.95	1291.6	2	1,330 lbs.
Barley	do	1.00	1.17	.28	1.45	1971.5	2	87.29 bu.
Oats........	do	8.51	1.39	.40	1.79	2433.9	2	74.67 bu.
Barley	do	4.42	1.96	.42	2.38	3236.0	2	68.59 bu.
Red Clover.	do	7.26	2.70	.44	3.14	4269.2	4	5.02 tons.
Red Clover.	do	35.90	1.79	.44	2.22	3018.3	3	....
Alfalfa.....	Yellowstone	53.40	1.30	.44	1.74	2365.8	1	5.17 tons.
Orchard ...	Ravalli	40.00	1.46	.13	1.59	2161.9	4	....
Oats........	do	161.70	1.30	.13	1.43	1944.3	2	33.37 bu.
Oats........	do	102.2	6.06	.13	6.19	8416.0	2	34.03 bu.

* About two-fifths irrigated on second irrigation. † Irrigation water.

THE AMOUNT OF WATER REQUIRED.

In the spring of 1900, a tract of land on the western edge of the Station farm was set apart for experiments on the proper amount of water to apply in irrigation. Sixteen rectangular plats 50x100 feet were laid off, with an intervening space between every two plats. A flume (Fig. 1) extended along the west edge of the row of plats and conveyed water from the nearest ditch to each plat. The amount of water applied to any one plat was measured by a weir box at the head of the flume.

All plats were seeded to oats May 21, 1900, at the rate of two bushels of seed per acre. On May 30 the percentage, by weight, of soil moisture in the upper two feet of soil over the entire number of plats ranged from 17.29 to 20.95 and averaged 18.95 per cent. The following table gives the results obtained on plats No. 1 to 8, inclusive. Plat No. 1 was not irrigated, but it received some moisture from an adjacent ditch.

No. of Plat.	Depth of Irrigation in Inches.	Yield per Acre.		Yield per Acre of Grain and Straw Tons.	Water Used per Acre. Tons.	No. Tons Water Applied for Each Ton Produce.
		Grain Bushels.	Straw Pounds.			
1..................	0	46.1	1655	1.61		
2..................	2	61.7	2345	2.29	227	99
3..................	8	68.2	2823	2.57	906	353
4..................	9	73.5	2988	2.74	1020	372
5..................	12	74.8	3075	2.81	1360	484
6..................	16	78.2	3398	3.03	1813	599
7..................	20	77.6	3284	2.96	2266	765
8..................	24	83.5	3215	3.03	2719	898

DISCHARGE OF THE PRINCIPAL RIVERS OF MONTANA.

For several years the irrigation department of the Station has supervised and conducted the hydrographic work of the U. S. Geological Survey in Montana. Gaging stations are established and maintained at favorable locations on the principal rivers of the State and measurements made of the flow at each station from four to twelve times during each year. An observer residing near the gaging station observes and records the height of water at least once a day. These records are mailed to the Experiment Station and are forwarded from thence to Washington, D. C. The data obtained from a number of stream measurements, together with the daily records of the observer, enable the engineer to compute with reasonable accuracy the daily flow, or discharge, throughout the year. The records for the year 1900 have been thus computed and are herein given for the following rivers: Yellowstone, Gallatin, West Gallatin, Middle creek, Madison, Jefferson, Missoula, Big Blackfoot, Bitter Root and Milk river. It should be observed that when ice forms on the surface of a stream neither the gage heights nor the flow can be accurately determined. In the accompanying tables the discharges are given in cubic feet per second. Since 40 Montana miners' inches are equivalent to one cubic foot per second the flow may be converted into miners' inches by multiplying the figures given by the number 40.

Daily Discharge of West Gallatin River, in Second-feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct,	Nov.	Dec.
1	700	560	500	630	1200	4165	1300	560	440	560	500	330
2	700	560	500	700	1300	3610	1300	560	440	560	500	330
3	700	560	500	700	1460	4570	1105	560	440	500	500	358
4	700	560	500	700	1745	4900	935	580	560	560	500	385
5	700	630	500	775	1995	4985	935	580	560	560	500	440
6	700	630	500	850	2610	5410	935	500	560	560	500	440
7	700	630	500	1020	2327	4827	935	500	560	560	500	440
8	630	630	500	850	2465	4325	935	500	530	500	500	385
9	630	630	500	775	2610	4405	935	500	440	500	500	385
10	630	630	500	775	3223	4165	850	500	440	500	500	385
11	630	630	500	775	4005	4652	850	500	440	500	440	385
12	630	440	500	775	4005	3145	850	500	385	500	385	385
13	630	440	500	775	3223	3223	775	500	440	500	440	385
14	630	440	500	775	2835	3223	775	500	440	500	440	385
15	560	440	500	775	2760	3533	775	500	500	500	440	385
16	560	440	500	850	2610	3145	700	500	440	500	440	358
17	560	440	500	775	2610	2835	700	518	440	500	440	330
18	560	440	500	850	2685	2610	700	......	500	500	385	330
19	560	440	500	935	2395	2685	700	500	500	500	330	330
20	560	440	500	1062	2535	2760	700	500	500	500	280	330
21	560	560	500	1200	2610	2835	630	500	500	385	280	330
22	560	560	500	1352	2990	2685	700	500	440	440	330	330
23	560	560	500	1572	3067	2685	630	500	560	500	330	330
24	560	560	500	1250	3377	2685	630	518	500	500	330	358
25	560	560	500	1105	3533	1995	630	518	500	500	330	358
26	560	560	500	1200	4325	1995	630	560	500	500	330	330
27	560	560	500	1200	5155	1630	665	530	500	440	330	330
28	560	500	500	1300	5410	1405	630	530	560	385	330	330
29	560	......	630	1300	4652	1405	560	530	500	385	330	330
30	560	......	630	1200	4652	1300	616	500	518	440	330	330
31	560	......	630	......	4005	......	630	440	......	440	......	320

Daily Discharge of Madison River, Near Red Bluff, in Second Feet, for 1900. (Including Cherry Creek)

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	......	(a)	860	3005	4840	2075	1640	1640	1850	1850	1640
2	....	(a)	......	860	3645	4305	2075	1640	1640	1850	1850	1640
3	....	......	......	860	4040	5110	1963	1640	1640	1850	1850	1640
4	(a)	......	......	1430	4040	5110	1850	1640	1640	1850	1640	1640
5	....	......	......	1430	4173	5326	1850	1640	1640	1850	1640	1640
6	....	......	......	1430	3775	5380	1850	1640	1640	1850	1640	1640
7	....	......	......	1640	3908	5380	1850	1640	1640	1850	1640	1640
8	....	(a)	860	1430	4040	5110	1850	1640	1640	1850	1640	1640
9	....	......	......	1430	4173	5110	1850	1745	1640	1850	1640	1640
10	....	......	......	1430	4305	5110	1850	1850	1640	1850	1640	1640
11	(a)	......	......	1430	4624	4840	1850	1850	1850	1850	1640	1640
12	....	......	......	1430	4840	4705	1850	1850	1850	1850	1640	1640
13	....	......	......	1430	5110	4040	1850	1745	1640	1850	1640	1640
14	....	......	......	1430	4840	3775	1850	1640	1640	1850	1640	1640
15	....	(a)	860	1535	4438	3515	1850	1640	1640	1850	1640	1640
16	....	......	......	1640	4173	3260	1850	1640	1640	1850	1640	1640
17	....	......	......	1745	3775	4305	1850	1640	1640	1850	1640	1640
18	(a)	......	......	1850	3645	2648	1850	1640	1640	1850	1640	1640
19	....	......	......	1850	3260	2530	1850	1640	1640	1850	1640	1640
20	....	......	......	1850	3515	2300	1850	1640	1640	1850	1640	1640
21	....	......	......	1850	3593	2300	1850	1640	1640	1850	1640	1640
22	....	(a)	860	2075	3515	2300	1850	1640	1640	1850	1640	1640
23	....	......	......	2300	3645	2188	1850	1640	1640	1850	1640	1640
24	....	......	......	2530	3960	2075	1850	1640	1640	1850	1640	1640
25	(a)	......	......	2530	4173	2075	1850	1640	1640	1850	1640	1640
26	....	......	......	2530	4570	2075	1850	1640	1850	1850	1640	1640
27	....	......	......	2530	5110	2075	1850	1640	1850	1850	1640	1640
28	....	......	......	2530	5380	2075	1850	1640	1850	1850	1640	1640
29	....	......	860	2530	5655	2075	1850	1640	1850	1850	1640	1640
30	....	......	......	2577	5655	2075	1640	1640	1850	1850	1640	.....
31	....	......	......	......	5518	......	1640	1640	......	1850	......	.....

(a) Ice.

Daily Discharge of Jefferson River, at Sappington, in Second Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	......	(a)	2020	3870	5890	1870	600	515	1090	1590	1590
2	....	......	(a)	2170	3870	5705	1725	600	515	1205	1590	1590
3	....	......	(a)	2565	4050	5520	1590	600	515	1265	1590	1590
4	....	......	(a)	2810	4140	5705	1590	515	515	1364	1590	1590
5	....	......	(a)	2980	4410	5890	1455	515	600	1455	1590	1725
6	....	......	(a)	3150	4688	4050	1455	515	600	1495	1455	1725
7	....	......	(a)	3330	5058	5705	1455	515	600	1455	1455	1725
8	....	......	(a)	3330	5248	5705	1455	515	600	1455	1455	1725
9	....	......	(a)	3330	5613	5335	1325	515	600	1455	1455	1725
10	....	......	2325	3065	5985	5150	1325	515	685	1455	1455	1725
11	....	......	2020	2810	6365	4965	1205	515	685	1455	1455	1725
12	....	......	2020	2645	6850	4410	1205	515	685	1455	1455	1590
13	....	......	2020	2645	8050	4050	1205	515	685	1325	1455	1590
14	....	......	1870	2645	8665	4050	1090	515	685	1325	1455	1590
15	....	......	1870	2645	8973	3870	980	515	685	1325	1455	1590
16	....	......	1870	2810	9075	3690	875	515	685	1325	1455	1590
17	....	......	1725	2810	8773	3870	775	515	685	1325	1455	1455
18	....	......	1870	2810	8358	4050	775	515	775	1325	1455	1455
19	....	......	2020	2810	8050	4230	685	515	825	1205	1455	1455
20	....	......	2020	2980	7740	4410	685	515	875	1205	1455	1455
21	....	......	2170	2980	7445	3870	685	515	875	1205	1455	1455
22	....	......	2170	3150	7350	3420	685	515	875	1205	1455	1455
23	....	......	2325	3330	6948	2810	685	515	875	1325	1455	1455
24	....	......	2485	3420	6850	2645	685	515	875	1325	1455	1455
25	....	......	2485	3600	6655	2485	685	515	875	1325	1455	1455
26	....	......	2485	3690	6558	2325	600	515	980	1455	1455	1455
27	....	......	2405	3870	6460	2170	609	475	980	1455	1455	1455
28	....	......	2248	3870	6460	2095	600	475	980	1455	1455	1325
29	....	......	2020	3870	6655	2020	600	475	980	1455	1590	1325
30	....	......	1870	3870	6460	2020	600	515	980	1455	1590	1325
31	....	......	1870	......	6175	......	600	515	......	1590	......	1325

(a) Ice.

Daily Discharge of Gallatin River, at Logan, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	......	......	940	1575	3870	605	290	400	530	605	680
2	......	......	......	940	1575	3870	530	290	400	530	605	680
3	765	......	......	940	1638	4240	530	290	460	530	605	680
4	......	......	......	940	1950	4240	460	290	460	605	605	680
5	......	......	......	940	1950	4333	460	290	460	643	605	680
6	......	......	......	940	2210	4615	460	290	460	680	605	680
7	......	1030	1345	940	2665	4520	460	290	460	680	605	680
8	......	......	......	940	2505	4055	460	345	460	680	605	680
9	......	......	......	940	2665	3685	400	345	460	605	605	686
10	850	......	......	940	3078	3415	345	345	460	605	605	605
11	......	......	......	940	3595	2585	345	345	460	605	605	605
12	......	......	......	940	4055	2210	290	345	460	605	605	605
13	......	......	......	940	4240	2210	240	345	460	605	605	605
14	......	(a)	940	940	3415	2013	240	345	460	605	605	605
15	......	......	......	1030	3243	1763	240	345	460	605	605	605
16	......	......	......	1030	2995	1575	240	345	460	605	605	605
17	850	......	......	1030	2995	1575	240	345	460	605	605	605
18	......	......	......	1130	2995	1460	240	345	460	605	723	605
19	......	......	......	1130	2995	1235	240	345	530	605	895	605
20	......	......	......	1130	2995	1235	240	345	530	605	1030	605
21	......	(a)	1030	1130	2995	1080	240	345	530	605	1080	605
22	......	......	......	1130	2995	1030	240	345	530	605	1030	605
23	......	......	......	1345	2995	1030	240	345	530	605	940	605
24	1030	......	......	1460	3078	1030	240	345	530	605	850	605
25	......	......	......	1575	3505	940	240	315	530	605	765	605
26	......	......	......	1638	3685	940	240	400	530	605	680	605
27	......	......	......	1575	4333	850	290	400	530	605	680	605
28	......	1030	850	1575	4805	765	290	400	530	605	680	605
29	......	......	......	1575	4805	680	290	400	530	605	680	605
30	......	......	......	1575	4055	605	290	400	530	605	680	(a)
31	1030	......	......	......	4240	......	290	400	......	605	......	(a)

(a) Ice.

Daily Discharge of Yellowstone River, above Livingston, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	(a)	......	1265	2490	10660	7270	3395	2100	1715	1500	1305
2	......	(a)	......	1340	2855	11540	6945	3270	2100	1733	1500	1355
3	......	(a)	......	1420	3060	12485	6600	3240	2050	1760	1500	1340
4	......	(a)	......	1500	4075	12975	6470	3130	2050	1733	1500	1340
5	......	(a)	......	1500	4730	13725	6220	3060	2050	1715	1500	1340
6	1380	(a)	(a)	1500	5980	15080	5980	3060	2050	1715	1500	1340
7	......	(a)	(a)	1670	5740	15363	5812	2990	2000	1715	1475	1340
8	......	(a)	(a)	1950	5623	13375	5575	2990	2000	1688	1460	1340
9	......	(a)	(a)	1850	6920	14530	5505	2923	1950	1670	1460	1340
10	......	(a)	(a)	1585	8970	11315	5345	2855	1950	1645	1420	1340
11	......	(a)	(a)	1585	10375	10875	5165	2790	1900	1628	1355	1340
12	......	(a)	(a)	1585	11540	10455	5005	2725	1900	1585	1340	1340
13	1420	(a)	(a)	1585	9140	10250	4830	2725	1900	1585	1395	1190
14	......	(a)	1340	1628	7215	11773	4690	2665	1900	1585	1420	1265
15	......	(a)	......	1628	5980	12730	4630	2665	1850	1545	1380	1265
16	......	(a)	......	1585	5930	12485	4495	2605	1823	1585	1460	1265
17	......	(a)	......	1585	6420	12150	4345	2548	1805	1585	1395	1265
18	......	(a)	......	1585	6220	11090	4305	2490	1805	1585	1305	1265
19	......	(a)	......	1670	5670	10660	4250	2490	1850	1585	(a)	1265
20	1340	(a)	......	1950	5860	11090	4160	2433	1850	1545	(a)	1265
21	......	1340	1265	2150	6170	11090	4075	2433	1805	1585	(a)	1265
22	......	....	......	2375	6600	11315	4040	2433	1805	1545	(a)	1265
23	......	....	......	2923	7070	11605	3900	2375	1760	1585	(a)	.....
24	......	....	......	2605	7550	10373	3815	2375	1760	1585	1190	1120
25	......	....	......	2665	7933	10170	3730	2375	1760	1545	1205	1190
26	......	....	......	2490	9955	9860	3730	2375	1733	1545	1340	1155
27	......	1340	......	2375	12485	9245	3730	2318	1715	1545	1380	1155
28	......	....	......	2490	14805	8570	3655	2318	1715	1545	1340	1030
29	......	....	......	2665	13375	8150	3575	2260	1715	1545	1265	1030
30	......	....	......	2923	11450	7935	3500	2205	1715	1500	1265	.....
31	......	....	1265	.....	10660	......	3420	2150	......	1500	......	(a)

a Ice.

Daily Discharge of Milk River, at Havre, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	......	......	......	355	355	76	21	30	76	129	(a)
2	.....	......	......	......	438	315	76	12	12	76	129	(a)
3	.....	......	......	......	396	280	63	12	12	91	129	(a)
4	.....	......	......	......	315	216	63	12	12	109	109	(a)
5	.....	......	......	......	280	216	63	12	39	149	109	(a)
6	.....	......	......	......	248	216	63	12	39	355	109	(a)
7	.....	......	......	......	216	216	50	12	50	355	109	(a)
8	.....	......	......	......	189	189	50	8	76	280	109	(a)
9	.....	......	......	......	189	189	63	8	91	248	109	(a)
10	.....	......	......	485	169	149	76	8	169	216	76	(a)
11	.....	......	......	485	149	149	91	12	149	189	63	(a)
12	.....	......	......	840	129	149	50	232	149	189	109	(a)
13	.....	......	......	587	149	129	50	203	149	169	149	(a)
14	.....	......	......	587	149	129	39	149	76	169	109	(a)
15	.....	......	......	485	189	129	39	109	76	248	169	(a)
16	.....	......	......	438	820	129	39	76	63	280	(a)	(a)
17	.....	......	......	315	1575	129	39	63	63	315	(a)	12
18	.....	......	......	396	1205	149	39	39	63	280	(a)	12
19	.....	......	......	280	880	109	30	30	63	248	(a)	12
20	.....	......	......	280	640	109	30	30	63	216	(a)	12
21	.....	......	......	280	587	109	30	21	76	216	(a)	12
22	.....	......	......	280	760	109	30	21	109	149	(a)	30
23	.....	......	......	280	587	109	21	12	109	149	(a)	(a)
24	.....	......	......	355	485	91	21	12	91	129	(a)	(a)
25	.....	......	......	438	438	91	21	12	76	129	(a)	(a)
26	.....	......	......	438	396	109	21	12	76	129	(a)	(a)
27	.....	......	......	280	355	91	21	12	76	129	(a)	(a)
28	.....	......	......	355	280	91	30	12	63	129	(a)	(a)
29	.....	......	......	280	315	91	21	12	63	129	(a)	(a)
30	.....	......	......	315	280	76	21	12	76	109	(a)	(a)
31	.....	......	......	......	315	......	21	30	......	109	......	(a)

(a) Ice.

Daily Discharge of Middle Creek, above Flander's Mill, in Second-Feet, for 1900.

Day	June	July	Aug.	Sept.	Oct.	Day	June	July	Aug.	Sept.	Oct.
1....	......	118	66	48	48	16....	......	88	51	48	......
2....	......	118	66	48	48	17....	......	88	51	48	......
3....	......	88	66	48	48	18....	232	88	51	48	......
4....	......	88	66	48	48	19....	192	88	51	50	......
5....	......	118	88	48	48	20....	232	88	51	50	......
6....	......	88	66	48	48	21....	321	66	51	50	......
7....	......	88	66	48	48	22....	232	66	50	48	......
8....	......	118	66	48	48	23....	368	66	50	48	......
9....	......	118	66	48	48	24....	232	66	50	48	......
10....	......	118	57	48	48	25....	232	88	50	48	......
11....	......	118	57	48	48	26....	192	66	50	48	......
12....	......	88	55	48	48	27....	192	66	50	48	......
13....	......	88	53	48	48	28....	192	88	50	48	......
14....	......	88	53	48	......	29....	163	66	50	48	......
15....	......	118	51	48	......	30....	118	66	48	48	......
						31....	......	66	48	......	......

Daily Discharge of Bitter Root River, Near Missoula, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1255	1255	......	1930	......	7210	3570	950	1080	1165	1880	1123
2	1165	1255	......	2040	......	7355	3260	950	1080	1080	1930	1123
3	1123	1255	......	2540	6400	8100	3110	930	1010	1080	1930	1123
4	1123	1165	910	3035	7070	9000	2680	910	950	1165	1730	1123
5	1165	1045	930	3570	8700	9600	2540	890	950	1165	1635	1165
6	1165	1010	930	3810	9600	10200	2475	870	1010	1123	1635	1165
7	1165	980	980	3975	10800	10650	2475	870	1045	1165	1445	1255
8	1165	950	1045	3730	10500	9300	2475	870	1045	1210	1350	1350
9	1123	950	1080	3490	9750	8700	2280	870	1010	1210	1540	1255
10	1080	980	1080	3410	10950	7800	2220	870	1010	1165	1350	1255
11	1080	(a)	1255	3335	12650	6400	2220	870	1010	1165	1255	1165
12	1123	(a)	1303	3260	14638	6150	1930	853	980	1165	1210	1123
13	1165	(a)	1350	3335	18150	6150	1830	853	980	1080	1210	1080
14	1350	(a)	1445	3260	15200	5910	1830	853	950	1045	1165	1080
15	1540	(a)	1493	3260	11700	5910	1730	853	950	1045	1165	1080
16	1540	(a)	1683	3410	10200	8700	1635	853	950	1010	1165	1080
17	1445	(a)	1830	3730	10350	8250	1540	853	1350	1010	1165	1165
18	1398	(a)	1930	4145	10500	7800	1445	853	1350	1045	1165	1165
19	1350	(a)	1985	4230	10650	7500	1398	835	1350	1045	(a)	1255
20	1350	(a)	2040	4320	9600	6795	1398	835	1255	1080	(a)	1255
21	1255	(a)	2040	4410	8400	7210	1255	800	1255	1165	(a)	1255
22	1210	(a)	2100	4600	8700	7500	1210	800	1255	1255	(a)	1255
23	1210	(a)	2100	4410	8400	7650	1165	800	1210	1350	(a)	1255
24	1210	(a)	2160	4230	8250	7500	1165	835	1255	1445	(a)	1165
25	1123	(a)	2160	4060	8100	7800	1123	835	1255	1165	1255	1165
26	1123	(a)	2280	4060	8100	6660	1123	835	1350	1540	1165	1165
27	1123	(a)	2160	3975	8250	5670	1123	853	1350	1730	1165	1080
28	1165	(a)	2040	3975	8250	4800	1123	870	1350	1780	1165	1010
29	1165	......	2100	......	8250	4230	1123	870	1255	1780	1165	950
30	1165	......	1930	......	7355	4060	1010	950	1255	1830	1123	950
31	1255	......	1930	......	6795	......	980	1010	......	1880	......	950

(a) Ice.

Daily Discharge of Big Blackfoot River, Near Bonner, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	824	743	662	1310	3514	3908	1830	1026	986	824	743	(a)
2	824	662	662	1391	3988	4064	1781	1026	905	824	743	(a)
3	905	662	702	1435	3988	4064	1733	986	905	824	783	(a)
4	864	662	581	1733	4160	4064	1643	986	905	824	743	(a)
5	783	702	380	1980	5106	3749	1643	986	905	824	783	(a)
6	702	621	420	2325	5877	3988	1553	986	905	824	824	1067
7	824	662	500	2520	6005	3749	1553	986	905	743	783	986
8	783	581	702	2650	5877	3514	1512	986	905	743	783	824
9	783	540	905	2715	5363	3514	1472	945	824	824	783	743
10	783	621	1512	2585	6005	3357	1472	1026	824	824	824	702
11	783	702	2085	2585	6648	3125	1391	986	905	743	783	783
12	702	702	2980	2520	8061	2980	1391	905	905	743	743	702
13	945	581	3125	2455	12559	2910	1391	905	905	743	783	702
14	905	581	2085	2325	11274	2980	1391	905	905	743	702	702
15	864	540	1781	2455	9989	2980	1310	905	824	743	743	662
16	864	460	1598	2520	8704	3125	1350	1067	824	824	743	662
17	783	621	1643	2520	9089	3592	1350	905	824	945	783	581
18	864	540	1350	2520	8961	3514	1269	1067	905	783	662	621
19	864	702	1391	2780	8575	3125	1229	905	824	702	702	621
20	743	662	1148	2980	7676	2910	1269	864	824	702	(a)	662
21	783	662	1107	3200	7290	2980	1229	905	905	662	(a)	864
22	824	702	1107	3278	7162	2845	1188	905	824	743	(a)	905
23	743	702	1188	3592	6391	2715	1107	905	824	702	(a)	783
24	662	662	1269	3749	6391	2650	1026	905	824	783	(a)	824
25	702	662	1229	3671	5877	2520	1026	805	824	702	(a)	783
26	743	581	1188	3671	5234	2325	1148	905	743	743	(a)	824
27	662	621	1269	3671	5106	2200	1229	905	743	824	(a)	783
28	702	621	1310	3435	4977	2085	1067	905	824	783	(a)	702
29	702	......	1188	3357	4977	2030	1067	864	824	743	(a)	702
30	743	......	1229	3278	4720	1880	1107	945	824	783	(a)	702
31	743	......	1310	......	3988	......	1107	864	......	743	......	581

(a) Ice

Daily Discharge of Missoula River, at Missoula, in Second-Feet, for 1900.

Dy.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	(a)	1534	2480	6540	9400	3260	1404	1278	1430	1560	(a)
2	(a)	(a)	1560	2645	6880	9050	3160	1340	1245	1495	1560	(a)
3	(a)	(a)	1495	3160	7475	9050	2980	1404	1300	1470	1560	(a)
4	(a)	(a)	1365	3560	8175	8875	2760	1340	1278	1664	1625	(a)
5	(a)	(a)	980	4100	9155	......	2678	1245	1404	1600	1664	1860
6	(a)	(a)	1030	4400	10000	......	2678	1245	1404	1560	1625	1885
7	(a)	(a)	1365	4900	10600	8175	2645	1190	1495	1664	1625	1820
8	(a)	(a)	1560	4650	10120	8175	2513	1190	1430	1625	1625	1820
9	(a)	(a)	2595	4725	9800	7755	2430	1245	1404	1560	1600	1690
10	(a)	(a)	3600	4475	11120	7580	2315	1135	1365	1560	1625	1600
11	(a)	(a)	5490	4400	12950	6775	2232	1300	1365	1534	1534	1470
12	(a)	(a)	6950	4400	23600	6240	2150	1245	1300	1495	1430	1365
13	1690	(a)	6300	4225	23600	5940	2070	1245	1278	1495	1430	1300
14	1950	(a)	4025	4350	20550	5550	2025	1223	1245	1470	1470	1300
15	1730	(a)	3400	4275	17980	5700	1950	1190	1278	1495	1430	1365
16	1664	(a)	2545	4475	16200	5940	1885	1190	2348	1495	1430	1340
17	1534	450	2760	4475	16850	6775	1860	1080	1600	1470	1600	1365
18	1560	930	2645	4400	16700	7580	1820	1113	1625	1430	(a)	1340
19	1560	(a)	2215	4725	15850	6390	1755	1113	1690	1470	(a)	1300
20	1560	(a)	2348	5100	15450	6000	1625	1080	1664	1470	(a)	1340
21	1600	(a)	2392	5350	13950	5575	1534	1030	1625	1430	(a)	1664
22	1534	1495	2480	5850	13100	5490	1470	1245	1560	1560	(a)	1885
23	1534	1534	2678	6150	12850	5150	1534	1278	1560	1560	(a)	1560
24	1495	1664	2513	6300	12120	5025	1495	1340	1625	1560	(a)	1430
25	1223	1664	2480	6300	11520	4900	1534	1404	1560	1534	......	1340
26	830	1625	2562	6450	10880	4900	1534	1430	1560	1495	(a)	1300
27	980	1625	2562	6450	10920	4400	1495	1430	1560	1470	(a)	1340
28	730	1625	2562	6300	11000	4025	1495	1340	1534	1495	(a)	1190
29	(a)	......	2430	6300	10600	3700	1534	1300	1534	1600	(a)	1013
30	(a)	......	2265	6300	10000	3460	1430	1365	1430	1534	(a)	980
31	(a)	......	2348	......	9600	......	1430	1340	......	1560	......	(a)

(a) Ice

INDEX.

BULLETINS 29 to 32.

BULLETIN NO. 33.

MONTANA AGRICULTURAL

EXPERIMENT STATION

...OF...

THE AGRICULTURAL COLLEGE OF MONTANA.

SUGAR BEETS IN MONTANA,

THE CROP OF 1901.

SUGAR BEET SERIES NO. 2.

BOZEMAN, MONTANA, JANUARY 1902.

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All communications for the Experiment Station should be addressed to the Director,

MONTANA EXPERIMENT STATION,

Bozeman, Montana.

The Bulletins of the Experiment Station are sent free to all residents of this state upon request.

Montana Experiment Station.

Bulletin No. 33 - - - - - - January, 1902.

SUGAR BEETS IN MONTANA.

CROP OF 1901.

F. W. TRAPHAGEN.

The results of sugar beet culture in Montana for the past season have been most gratifying, and we feel renewed confidence in the opinion expressed in Bulletin No. 19, that "Montana conditions are favorable to the production of sugar beets of high sugar content and standard purity."

Great interest has been taken in the sugar beet work this year, because, for the first time, the question of our ability to meet the commercial conditions of this crop, has been taken up seriously by capitalists. Because of this, our work has been supplemented in two important agricultural valleys by others, and, on account of this additional interest, more attention has been given to careful culture. This attention is shown in the results, which, in general, are far better than in any preceding year.

On the Bitter Root Stock Farm in particular, a series of very careful tests were conducted, and the results, in richness, purity and yield, were such as to fully satisfy the most exacting. These tests were conducted by Mr. Thomas Loynd, an experienced sugar beet culturist, from Utah, and were made on different varieties of soil, including the poorer as well as the richer. A perusal of the tables containing the results of these tests will show very striking figures.

Sugar beets in the past have received very scant attention at the hands of those who have planted them in this state. Put in as an accommodation to the Experiment Station, they have been attended to after every other interest has been considered. When irrigated, if at all, they received water not when they most needed it, but when most convenient to the farmer. The same is true of cultivation, and this crop, which responds so readily to painstaking

care, has been left to grow almost unattended. In spite of this, the results have been very pleasing. Montana seems to be the natural habitat of root crops, and the difficulty is to keep down the growth, and prevent the formation of too large roots.

Even at the Experiment Station where the results have been such, that the culture would always have been profitable, both from the standpoint of the producer and of the manufacturer, the sugar beets have been part of a rotation, in which they have been far from being the favored crop.

In the valley of Clark's Fork of the Yellowstone River, the first experimental work was carried on the past year, with an outcome that would indicate this valley as an ideal locality for the establishment of a factory. In the three localities just mentioned, the experiments have been carried on in a sufficiently large scale, to demonstrate the question of profitable sugar beet culture to any who make a careful study of the conditions and results.

The yield, sugar content, and purity, can be kept far above the standards adopted as the minimum values, by sugar beet experts. as demonstrated by the past season's work, which can be improved upon as cultural conditions are bettered. Fuel is easily obtainable and cheap, water is pure and abundant, limestone of great purity is available and land sufficient to produce the crop, and at the same time sustain a logical three year's rotation, is at hand in each of these sections.

No doubt many other sections of the state could show just as good figures, but, unfortunately, the experiments have been lacking in magnitude sufficient to satisfy the intending investor. Many results have been obtained by farmers in different portions of the state, which are entirely satisfactory in themselves, but, which, in order to possess their full value, must be supplemented by experiments by their neighbors.

A factory will not be established anywhere where there is not at least fifteen thousand acres of land within easy reach of the factory, either by rail or country road, which will contribute the beet crop to the factory. This amount of land planted to a three year rotation of clover, grain and beets, would maintain a factory of fair size, but, a smaller area of available land would hardly be considered.

It is the custom of the beet sugar companies to pay for the railroad haul, and where the beets are siloed, to await their call, they pay twenty cents additional per ton. The method of siloing in use is very simple, consisting only in making a trench more or less deep, and as wide as necessity demands, and, after filling with beets, covering over with the loose soil previously removed.

The consumption of sugar in Montana is sufficient to use up all the product of at least one large factory and the protection afforded by the long freight haul, with attendant high tariffs, together with the excellent crop returns, will certainly prove incentives, sooner or later, to the establishment of factories within our borders.

Feeding Beets and Pulp.

Until the product of the sugar beet fields is absorbed by beet sugar factories, and while the experimental work, necessary to prove the claims of various localities, is going on, the roots can be very profitably fed to stock, and prove a very welcome addition to the ordinary dry ration, as well as yielding a distinct gain in flesh, equivalent to a high money return for the beets fed.

The striking results obtained at the Montana Experiment Station in swine feeding experiments, conducted by Prof. Shaw, which are described in Bulletin No. 27, to which readers of this Bulletin are referred, will show the value of beets as food.

This subject has been previously taken up in Bulletin No. 19, and work subsequent to that publication, shows that as a succulent addition to the usual food, the beet is valuable and acceptable. This is particularly true in our own state, where succulent foods are so scarce, especially in winter.

Climate.

The old saying "that the proof of the pudding is in the eating" applies particularly to the discussion of the Montana climate in reference to sugar beet culture. When we can get yields of 25.6 tons per acre, of beets of 19.38 per cent sugar content, and 86.4 per cent purity, as was done in one specially favored portion of the Bitter Root Stock Farm, and when almost every valley in the state produces crops of beets above the general commercial average, who will say the Montana climate is not adapted to sugar beets?

Experiment Station—Variety Tests.

Lab'y No.		Av. Wt. Oz.	Sugar in juice	Sugar in beet	Purity Coef.	Date 1901
1805	Miscellaneous	20.00	16.8	15.96	84.44	Sept. 19
1831	Kleinwanzlebener, 5770	24.8	15.8	15.3	81.00	Sept. 28
1832	Utah Seed	25.4	16.5	15.67	85.5	Sept. 28
1833	Zehringen, 3942	16.8	15.6	14.82	88.2	Sept. 28
1834	Braune, 2885	23.00	16.1	15.19	83.3	Sept. 28
1835	Kleinwanzlebener, Dippe, 3944	19.6	16.3	15.58	82.02	Sept. 28
1836	Kleinwanzlebener, Russia, 3943	23.4	15.00	14.25	78.00	Sept. 28
1837	Vilmorin	20.2	15.8	15.01	79.7	Sept. 28
1838	Unknown Variety	20.4	16.6	15.77	85.5	Sept. 28
1842	Kleinwanzlebener, 5770	20.5	16.1	15.29	76.3	Oct. 5
1843	Utah Seed	21.00	17.9	17.00	87.5	Oct. 5
1844	Zehringen, 3942	22.00	15.9	15.10	74.6	Oct. 5
1845	Braune, 2885	20.00	17.7	16.71	82.3	Oct. 5
1846	Kleinwanzlebener, Dippe, 3944	19.00	19.5	18.52	88.6	Oct. 5
1847	Kleinwanzlebener, Russia, 3943	18.00	17.6	16.72	86.1	Oct. 5
1848	Vilmorin	26.5	14.00	13.3	72.9	Oct. 5
1869	Kleinwanzlebener, 5770	25.5	17.0	16.15	86.00	Oct. 12
1870	Utah	17.00	18.5	17.57	84.9	Oct. 12
1871	Zehringen, 3942	15.5	18.3	17.38	83.3	Oct. 12
1872	Braune, 2885	16.5	18.5	17.57	86.3	Oct. 12
1873	Kleinzwanzlebener, Dippe, 3944	14.00	19.1	18.14	90.5	Oct. 12
1874	Kleinwanzlebener, Russia, 3943	14.5	18.6	17.67	88.5	Oct. 12
1875	Vilmorin	17.00	19.2	18.24	87.6	Oct. 12
1882	Kleinwanzlebener, 5770	15.00	18.4	17.48	82.9	Oct. 19
1883	Utah	18.00	19.3	18.33	86.1	Oct. 19
1884	Zehringen, 3942	14.66	20.00	19.00	87.00	Oct. 19
1885	Braune, 2885	16.66	19.9	18.9	87.6	Oct. 19
1886	Kleinzwanzlebener, Dippe, 3944	18.66	18.3	17.38	85.9	Oct. 19
1887	Kleinwanzlebener, Russia, 3943	14.66	18.2	17.29	86.6	Oct. 19
1888	Vilmorin	17.00	17.9	17.00	84.00	Oct. 19
1966	Kleinwanzlebener, 5770	20.8	17.90	17.00	81.8	Oct. 26
1967	Utah	17.4	20.10	19.05	85.00	Oct. 26
1968	Zehringen, 3942	20.00	19.70	18.76	85.5	Oct. 26
1969	Braune, 2885	21.00	19.70	18.74	87.00	Oct. 26
1970	Kleinwanzlebener, Dippe, 3944	23.00	19.50	18.46	88.00	Oct. 26
1971	Kleinwanzlebener, Russia, 3943	19.00	19.30	18.35	87.5	Oct. 26
1972	Vilmorin	22.00	17.97	17.07	86.00	Oct. 26

Averages of all Tests.—Experiment Station.

	Av. weight ounces	Sugar in juice	Sugar in beet	Purity Coef.	Tons per acre	Lbs. sugar per acre
Kleinwanzlebener, 5770	21.32	17.04	16.31	81.6	13.5	4403
Utah	19.76	18.44	17.51	85.8	11.7	4007
Zehringen, 3942	17.8	17.91	17.01	83.7	11.45	3895
Braune, 2885	19.43	18.38	17.42	85.3	10.5	3658
Kleinwanzlebener, Dippe, 3944	18.85	18.53	17.61	87.00	10.4	3662
Kleinwanzlebener, Russia, 3943	17.91	17.75	16.85	85.3	9.25	3117
Vilmorin	20.5	17.13	16.27	84.00	9.5	3091
General Average	19.37	17.88	16.98	84.9	10.9	3690

Averages for Successive Dates.—Experiment Station.

Date 1901.	Av. weight	Per cent sugar in juice	Per cent sugar in beet	Per cent purity
September 28	21.7 oz.	15.96	15.20	82.90
October 5	21.0 oz.	16.96	16.13	81.19
October 12	17.14 oz.	18.46	17.53	86.73
October 19	16.38 oz.	18.86	17.92	85.73
October 26	20.45 oz.	19.18	18.25	85.83

Clark's Fork Valley.—Bridger and Gebo.

The * indicates that the P. O. address is Gebo; the address of all others is Bridger.

Lab'y No.	Name.	Av. weight in ounces	Sugar in juice	Sugar in beet	Purity Coef.	Tons beets per acre	Lbs. sugar per acre
1850	P. R. Miller *	8.8	17.1	16.22	79.9	6.5	2108
1854	C. F. Sexton	29.00	15.9	15.10	80.3	25.00	7552
1881	A. E. Parker	31.5	14.3	13.58	69.4	9.00	2444
1889	William Barclay	14.7	16.2	15.39	78.2	12.00	3695
1891	James Barclay	19.43	21.3	20.23	82.88	20.00	8092
1903	C. M. Larkin	10.8	16.88	16.00	80.00		
1907	W. H. Bostic	24.9	19.5	18.52	78.3	20.00	7408
1934	C. H. Bostic	9.4	15.5	14.72	67.1		
1935	W. F. Gibson	35.5	18.00	17.1	74.4	24.00	8208
1936	Lucy H. Smith	28.00	20.1	19.09	83.7	20.00	7636
1937	Hugh Morrow	26.5	19.7	18.71	74.5	15.00	5613
1938	R. B. Teesdale		18.8	17.86	85.4	25.00	8930
1939	E. T. Bostic	28.5	21.9	20.8	88.3		
1940	J. R. Stevens	55.00	14.81	14.06	77.4	15.00	4218
1941	S. H. Mendenhall	14.8	18.11	17.2	83.8	20.00	6880
1942	Thomas Barnett	20.8	16.5	15.67	80.00	12.00	3760
1943	A. G. Duffield	32.00	17.8	16.9	83.00	25.00	8450
1944	L. G. Preno	24.5	17.9	17.00	79.6	20.00	6800
1945	F. O. Jennings	31.00	17.6	16.7	75.00		
1946	B. F. Bayler	33.00	22.7	21.56	85.3		
1947	Richard Barrows	25.5	18.6	17.67	82.00	20.00	7068
1952	I. A. Goff *	11.6	13.4	12.73	74.44	12.00	3055
1953	F. E. Stevens	21.00	16.00	15.20	82.05	25.00	7600
1954	Frank Hiser	9.2	19.3	18.33	84.65	15.00	5499
1955	E. D. Lovegreen	14.33	16.3	15.48	77.94	15.00	4644
1956	E. T. Preuitt	18.66	19.1	18.14	86.80	20.00	7256
1957	W.A. Cowan *	21.00	16.8	15.96	80.00		
1958	E. Cowan	15.4	19.8	18.81	90.00	20.00	7524
1959	N. Webber	18.6	18.7	17.76	86.12		
1960	C. M. Laughery	17.5	19.9	18.90	88.83	20.00	7560
1961	T. E. Stearns	18.66	14.7	13.96	76.96		
1950	R. A. Duncan (4)	25.00	17.7	16.8	80.00		

(4) P. O. Address is Rockvale.

Bitter Root Stock Farm.—Hamilton, Mont.

		Av. weight ounces	Sugar in juice	Sugar in beet	Purity Coef.	Tons per acre	Lbs sugar per acre
1855	Hamilton Ranch, No. 1	17.8	20.1	19.09	87.3	18.9	7216
1856	Hamilton Ranch, No. 2	16.6	19.3	18.33	86.9	13.6	4985
1857	Hamilton Ranch, No. 3	15.2	20.1	19.9	82.4	22.00	8756
1858	Hamilton Ranch, No. 4	8.8	21.1	20.04	87.5	12.7	5090
1859	Gilchrist Ranch, No. 1	11.00	20.6	19.57	88.4	18.4	7201
1860	Gilchrist Ranch, No. 2	11.6	22.00	20.9	91.2		
1861	Prendergast Ranch, No. 1	11.8	19.8	18.81	87.6	20.00	7524
1862	Prendergast Ranch, No. 2	13.6	22.1	20.99	92.00	18.00	7556
1863	Lower Ward Ranch, No.1	13.00	21.1	20.04	90.6	18.3	7334
1864	Lower Ward Ranch, No. 2	12.4	20.8	19.76	89.2	14.00	5532
1865	Upper Ward Ranch, No. 1	13.4	20.3	19.28	87.5	12.00	4627
1866	Ravalli Ranch	13.00	20.2	19.19	90.00	14.6	5603
1867	Corvallis Ranch	15.6	20.4	19.38	86.4	25.6	9922

Missoula County.

Lab'y No.	Name.	Av. Weight in ounces	Sugar in juice	Sugar in beet	Purity Coef	Tons beets per acre	Lbs. sugar per acre
	W. H. Daykin, Missoula						
1876	Kleinwanzlebener	17.5	17.3	16.43	77.5		
1877	Vilmorin	16.00	17.9	17.00	81.3	16.5	5610
1878	Utah	21.5	17.00	16.15	84.9	19.00	6137
	Chas. E. Coleman, Missoula.						
1924	Kleinwanzlebener	32.66	16.5	15.67	76.03	12.4	3886
1925	Vilmorin	19.5	19.7	18.71	86.4	11.5	4303
1932	**Henry Buckhouse, Missoula**	10.4	15.5	14.72	85.1	9.00	2650
	C. C. Willis, Plains						
1893	Kleinwanzlebener	10.8	17.4	16.53	87.7	11.00	3636
1894	Vilmorin	13.00	18.1	17.19	88.3	12.5	4297
1895	Utah	9.00	16.6	15.77	81.7	12.00	3784

Gallatin Valley.

Lab'y No...	Name.	Av. weight in ounces...	Sugar in juice......	Sugar in beet......	Purity Coef	Tons beets per acre...	Lbs sugar per acre...
1879	**John A. Moore, Belgrade......**	33.5	12.00	11.40	75.00		
1919	**W. A. Caldwell, Belgrade.....**	18.6	17.00	16.15	80.5	27.00	8721
	A. A. Spaulding, Bozeman....						
1930	Kleinwanzlebener	17.66	16.5	15.67	80.5	30.00	9402
1931	Vilmorin	25.66	15.4	14.63	78.5	36.00	10534
	M. M. Ferguson, Bozeman....						
1933	Kleinwanzlebener	19.00	16.4	15.58	80.00		

Cascade County.

Lab'y No...	Name.	Av. weight in ounces	Sugar in juice......	Sugar in beet......	Purity Coef	Tons beets per acre...	Lbs sugar per acre...
	Paris Gibson, Great Falls......						
1839	Utah	44.00	13.5	12.82	65.00		
1840	Kleinwanzlebener	30.00	11.6	11.00	63.00		
1841	Vilmorin	48.00	15.4	14.63	70.00		
1892	**C. H. Campbell, Great Falls...**	12.00	17.5	16.62	80.00		
1906	**John H. C. Dale, Great Falls...**	33.00	17.00	16.15	86.28	25.00	8075
	Daniel Payne, Monarch........						
1899	Utah	11.8	16.8	15.96	82.00		
1900	Kleinwanzlebener	9.66	19.2	18.24	80.3		
1901	Vilmorin	7.7	19.2	18.24	78.68		

Yellowstone County.

Lab'y No....	Name.	Av. weight in ounces..	Sugar in juice......	Sugar in beet......	Purity coef	Tons beets per acre...	Lbs sugar per acre...
1785	Wm. Birely, Billings..........	41.00	4.00	3.8	41.00		
1786	Wm. Birely, Billings	38.00	5.4	5.13	56.2		
1902	I. D. O'Donnell, Billings......	38.00	13.02	12.36	70.00		
1965	I. D. O'Donnell, Billings......	40.3	12.27	11.65	66.00		
1929	C. D. Hatch, Laurel..........	21.00	18.1	17.2	80.00		

Park County.

Lab'y No....	Name.	Av. weight in ounces	Sugar in juice......	Sugar in beet......	Purity Coef	Tons beets per acre...	Lbs. sugar per acre...
	L. M. Jones, Myersburg.......						
1920	Kleinwanzlebener	17.50	17.4	16.53	77.6	20.00	6612
1921	Vilmorin	18.00	16.00	15.20	70.17	21.00	6384
1922	Utah	32.00	14.5	13.77	69.04	47. *	12944
1897	Gus Nelson, Livingston........	23.66	16.9	16.05	78.00	20.5	6498
1948	Andrew Lyall, Livingston....	12.5	17.4	16.53	62.14		
1962	George J. Allen, Livingston...	15.5	18.5	17.57	81.5		

* Excluded from average.

Flathead County.

Lab'y No....	Name.	Av. weight in ounces	Sugar in juice......	Sugar in beet......	Purity coef	Tons beets per acre...	Lbs sugar per acre...
1896	Theodore Koenig, Kalispell...	14.00	21.2	20.14	81.7		
1904	Mc. C. Winiger, Kalispell.....	14.00	17.3	16.43	82.38	10.00	3286
1951	C. E. Pettit, Kalispell........	25.5	19.7	18.64	83.4	19.00	7083
	T. S. Proud, Kalispell.........						
1926	Utah	14.2	17.4	16.53	80.55	10.00	3306
1927	Vilmorin	21.2	17.7	16.8	78.00	14.00	4704
1928	Kleinwanzlebener	9.8	20.2	19.19	87.4	11.00	4222

Miscellaneous.

Lab'y No.	Name.	Av. weight in ounces	Sugar in juice	Sugar in beet	Purity Coef	Tons beets per acre	Lbs sugar per acre
1880	W. N. Aylesworth, Deer Lodge	32.00	16.00	15.2	88.00		
1852	James Fullerton, Red Lodge...	29.2	13.9	13.2	66.5	16.00	4224
1890	D. McNeil, Boulder..........	32.00	14.5	13.77	80.1		
1898	John Flaherty, Cold Springs..	14.00	12.6	11.87	85.9		
1853	J. S. Crowder, Lewistown....	17.00	15.4	14.63	71.6	23.00	7552
1923	R. Parkhurst, Victor..........	18.00	14.6	13.97	74.4		
1982	Sidney Ward, Hamilton........	15.6	21.00	19.95	90.5		
1868	W. M. Wooldridge, Hinsdale..	14.00	15.7	14.91	80.5	20.00	5964
1949	W. M. Wooldridge, Hinsdale..	24.8	14.7	13.96	84.9		
1963	Arthur Millard, Miles City....	16.00	18.4	17.48	78.01		
1851	John Bamber, Glendive.......	18.6	14.00	13.3	76.5		
1849	Geo. W. Dana, Deer Lodge....	11.8	15.3	14.53	75.7		

General Variety Tests.

(Exclusive of the Experiment Farm, Bitter Root Stock Farm, and Clark's Fork Valley.)

Variety.	Av. weight in ounces.	Sugar in juice.	Per cent of sugar in beets.	Per cent of purity.
Kleinwanzlebener	18.4	17.00	16.15	81.3
Vilmorin	21.4	16.85	16.00	79.2
Utah	21.5	16.00	15.20	75.99

LOCALITY AVERAGES.

Locality.	Av. weight in ounces	Sugar in juice....	Sugar in beet......	Purity Coef	Tons beets per acre...	Lbs. sugar per acre...
Cascade County (1)	24.5	16.25	15.4	75.4	25.00	8075
Yellowstone County	35.66	10.56	10.00	62.6		
Flathead County	16.45	18.9	17.95	82.24	12.8	4520
Valley County (1)	19.40	15.2	14.43	82.7	20.00	5968
Park County (2)	19.5	16.66	15.94	73.07	20.5	6498
Custer County (1)	16.00	18.4	17.5	78.00		
Dawson County (1)	18.6	14.00	13.3	76.5		
Powell County	21.9	15.6	14.86	81.8		
Fergus County	17.00	15.4	14.63	71.6	23.00	7552
Jefferson County	23.00	13.50	12.82	83.00		
Carbon County (3)	29.2	13.9	13.2	66.5	16.00	4244
Missoula County	16.7	17.3	16.46	83.00	13.00	4288
Ravalli County (4)	16.8	17.8	16.96	82.45		
Gallatin County (5)	22.88	15.46	14.68	78.9	31.00	9332
Bitter Root Stock Farm	13.37	20.60	19.64	87.46	16.5	6771
Experiment Farm	19.37	17.88	16.98	84.9	10.9	3690
Clark's Fork Valley	22.7	17.84	16.97	80.5	18.00	6174

(1). One lot only.
(2). One locality only.
(3). Excluding Clark's Fork Valley.
(4). Excluding Bitter Root Stock Farm.
(5). Excluding Experiment Farm.

COMPARISON OF YIELDS IN MONTANA AND ELSEWHERE.

Average Montana Results in 1901.

Locality.	Beets per acre Tons	Per cent sugar in the beets	Lbs. sugar per acre
Bitter Root Stock Farm	16.5	19.64	6771
Experiment Farm	10.9	16.98	3690
Clark's Fork Valley	18.00	16.97	6174
Cascade County (a)	25.00	15.40	8075
Flathead County	12.8	17.95	4520
Valley County (a)	20.00	14.43	5964
Park County	20.5	15.90	6498
Fergus County	23.00	14.63	7552
Carbon County (b)	16.00	13.20	4244
Missoula County	13.00	16.46	4288
Gallatin County (c)	31.00	14.68	9332

(a). One lot only.
(b). Excluding Clark's Fork Valley.
(c). Excluding Experiment Station.

Germany.

Years.	No. of factories.	Acreage.	Tons beets per acre.	Per cent sugar in beets.	Lbs. sugar per acre.
1890-1891	406	825,825	13.03	12.09	3150
1891-1892	403	861,583	11.41	12.06	2752
1892-1893	401	869,829	11.29	11.94	2696
1893-1894	405	945,995	11.12	12.34	2744
1894-1895	405	1,090,801	13.27	12.15	3225
1895-1896	397	930,749	12.55	13.11	3290
1896-1897	399	1,049,881	13.07	12.66	3309
1897-1898	402	1,079,810	8.62	12.79	2205
1898-1899	401	1,154,229	11.52	13.15	3029
1899-1900	399	1,154,355	11.79	14.4	3395
1900-1901	395	1,095,790	12.06	14.91	3596

COMPARISON OF YIELDS IN MONTANA AND ELSEWHERE.

France.

Years.	No. of factories.	Acreage.	Tons beets per acre.	Per cent sugar in beets.	Lbs sugar per acre.
1890-1891	377	547,574	11.3	10.7	2418
1891-1892	370	550,786	10.16	11.6	2357
1892-1893	368	537,690	9.77	10.9	2030
1893-1894	370	543,420	9.27	11.5	2132
1894-1895	367	596,803	12.21	10.15	2478
1895-1896	356	505,851	10.7	12.7	2558
1896-1897	358	608.370	11.37	10.8	2456
1897-1898	344	564,572	11.21	12.9	2892
1898-1899	344	590,347	10.49	13.34	2807
1899-1900	399	626,480	11.81	12.45	2941
1900-1901	342	685,391	10.79	15.01	3239

A careful scrutiny of these tables shows the steady increase in sugar per acre in Germany and France, under constantly improving methods of cultivation. But even with the extreme care in culture and the constant application of fertilizers, the results are far below those obtained in Montana, in every locality in which the experimental work has been carried on. Certainly in some of these localities we have good reason to hope for the location of a beet sugar factory soon.

For an explanation of terms and a general discussion of the problem, the reader is referred to Bulletin No. 19 of this Station, on Sugar Beets in Montana.

An extended Bulletin at this time has been considered unneccessary, for it is believed that the figures given "speak for themselves."

BULLETIN No. 34.

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

FARMERS' WEIRS.

ONE METHOD OF MEASURING WATER.

THIS PUBLICATION IS THE FIRST OF A SERIES OF FARMERS' BULLETINS ON IRRIGATION TOPICS.

Bozeman, Montana, February 1902.

REPUBLICAN,
Bozeman, Montana,
1902.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

BOZEMAN, - MONTANA.

Postoffice, Express and Freight Station. Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,

Bozeman, Montana.

NOTICE.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

BULLETIN NO. 34. - - - FEBRUARY 1902.

FARMERS' WEIRS.

BY S. FORTIER, DIRECTOR.

INTRODUCTION.

During the crop growing season the irrigators of Montana divert large volumes of water from the natural channels of the stream. When the natural supply is limited to the flow of a small creek a few farmers may convey the entire amount through small ditches. When the stream is large a score or more of canals, each supplying water to hundreds of farmers, may be in use. In all cases other than exclusive individual ownership the equitable division of irrigation waters is a necessity.

For a long period after the first settlement of the fertile valleys of the state, water was abundant and little attention was paid to accurate measurements, or a just division. In some favored sections these conditions still prevail. So long as water for irrigation is cheap and plentiful western farmers, as a rule, do not trouble their minds about either irrigation laws or suitable measuring devices. Until March 12, 1885 Montana had no legal standard for measuring water in motion. In that year the legislature enacted the following:

"Sec. 1262. The measurement of water appropriated under this chapter shall be conducted in the following manner: A box or flume shall be constructed with a head gate placed so as to leave an opening of six inches between the bottom of the box or flume and the lower edge of the head gate, with a slide to enter at one side of and of suffi-

cient width to close the opening left by the head gate by means of which the dimensions of the opening are to be adjusted. The box or flume shall be placed level, and so arranged that the stream in passing through the aperture is not obstructed by back water, or an eddy below the gate; but before entering the opening to be measured the stream shall be brought to an eddy, and shall stand three inches on the head gate and above the opening. The number of square inches contained in the opening shall be the measure of inches of water."

From 1885 to 1898 the miners' inch box just described was the only legal method of measuring irrigation water and the court decrees of that period in relation to all water right suits are expresssed in Montana statutory inches.

This box which was designed to measure miners' inches consisted generally of a short flume having a bottom and two sides. At the upper end a board three inches wide was fastened six inches above the top of the floor. The opening formed between the lower edge of the board and the floor was controlled by a slide, or gate, which moved horizontally. When the box was in place the irrigation stream to be measured was turned on and the slide so adjusted that the surface of the water at the upper end of the box was level with the top of the three inch board. It was an easy way of measuring water under a six inch pressure, for the distance from the top of the three inch board to the center of the opening was intended to be six inches. In measuring a stream if the slide were drawn out 15 inches at the time the water was level with the top of the three inch board the opening thus made would be six inches high and 15 inches long and contain 90 square inches. The amount of water flowing through this opening of 90 square inches under an average head of six inches would represent 90 miner's inches.

This method of measuring water has been severely criticised by the engineers of the state. Their objections may be summarized as as follows:

(1) It is not accurate.

(2) It can only be used to measure small streams.

(3) It is not adapted to continuous measurements.

(4) It favors the large consumer.

(5) The flow may be considerably increased or diminished by slight changes.

(6) Miners' inches vary in quantity in different localities of the West.

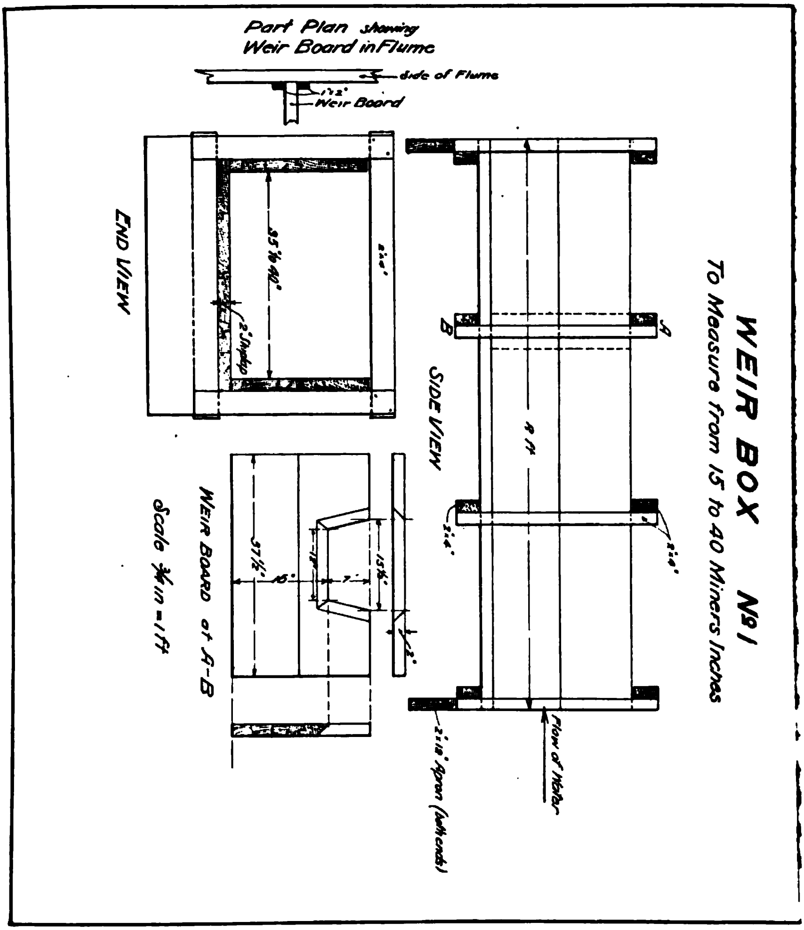
In 1898 the state legislature established a new standard unit, defined the Montana miners' inch and repealed all laws in conflict therewith. This enactment is still in force and the standard units with others will be described under the next heading.

DEFINITIONS.

Cubic Foot per Second.—The standard unit for flowing water in Montana as well as in most of the western states and territories, is a solid, or cubic foot of water, moving at the rate of a lineal foot in one second of time. Each foot in length of a flume one foot wide and one foot high inside measurement and flowing full of water would contain a solid or cubic foot of water. Now if this flume were placed on such a grade that the average rate of flow of water within it would be just one foot of distance for each second of time it would carry a volume equal to the standard unit. This unit is often abbreviated into the two words second-foot.

In considering this standard for flowing water, irrigators should not conclude that a volume of a certain definite size is necessary. It will be apparent to all that a flume six inches wide and six inches high full of water flowing at the average rate of 4 feet per second would also deliver one cubic foot per second. In general, the flow of any stream may be obtained by multiplying the width and depth of the water channel in feet by the average rate of flow in feet. A flume, for example, which is six feet wide inside and carries water to a depth of 1-½ feet would contain 6x1-½ or 9 square feet of water area. Now, if it is found that the average rate of flow is two feet per second the total volume is 2x9, or 18 subic feet per second. In the case of a ditch in earth with a curved bottom the area is not so readily found but the principle involved is the same.

Montana Miners' Inch.—Like the bushel measure for grain the term miners' inch is likely to be continued long after that method of water measurement has been abandoned. I do not know of a single Montana farmer that now measures his grain by means of a bushel measure and yet the large majority indicate their yields in bushels


Part Plan showing
Weir Board in Flume
Side of Flume
Weir Board
End View
Side View
Weir Board at A-B
Scale 1/4 in = 1 ft
WEIR BOX No 1
To Measure from 15 to 40 Miners Inches
Flow of Water

Bill of Material for Weir Box No. 1.

No. of Pieces.	Actual Dimensions.	B. M. Feet	Where Used.	Remarks.
	In. In. Ft. In			
4	2 x 12 x 8	64	Lining Sides.	Lumber, Rough.
3	2 x 12 x 8	48	Lining Bottom.	" "
1	2 x 10 x 8	13½	" "	" "
8	2 x 4 x 4 2	22⅓	Sills and Ties.	" "
8	2 x 4 x 2 10	15	Posts.	" "
2	2 x 12 x 4 2	16⅔	Aprons.	" "
2	2 x 12 x 3 1½	12½	Weir Board.	Clear Lumber Surface.
4	1 x 2 x 2	1¼	Cleats, sides.	" " "
2	1 x 2 x 3	1	Cleats, bottom.	" " "

7 lbs. 20d wire nails.

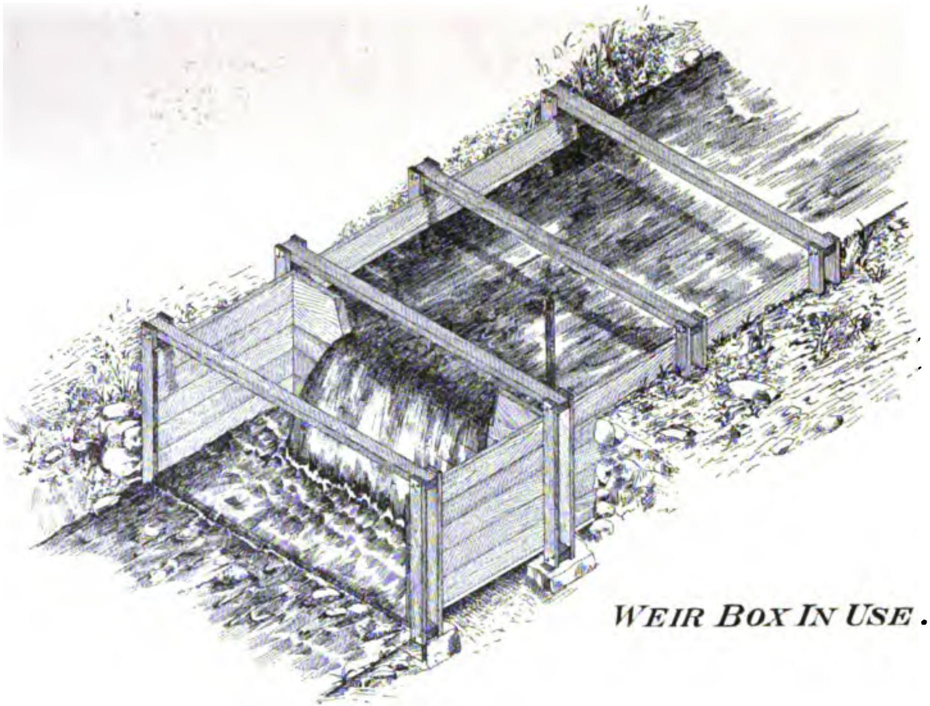
½ lb. 6d wire nails.

per acre. Scales of all kinds have now become so common that the old fashioned measure of our grandfather's time is no longer used. There have been like changes in the devices used to measure water and while we still retain the term miners' inch we seldom ascertain the flow by the miners' inch box. For small streams of water such as are applied to orchard and garden tracts the miners' inch is a convenient unit and there are advantages in continuing its use. In adopting a new standard the members of our state legislature foresaw the extended use of the old unit and so defined it in accurate terms. Forty (40)Montana miners' inches are the exact equivalent of one cubic foot per second. An irrigation stream containing 80 miners' inches would be described as two second-feet by the new standard, one containing 120 miners' inches as three second feet, and so on.

Acre-Foot.—The second-foot and the miners' inch can only be used for water in motion. It is often convenient in irrigation to describe a certain volume of water in a state of rest. The cubic foot might have been adopted for this purpose had it not been too small. It would have been but a drop in a bucket when compared with the large quantities used in irrigation. Accordingly the acre-foot has been quite generally udopted.

This unit represents the quantity of water which would cover an acre to the depth of one foot. Since there are 43560 square feet in an acre, an acre-foot contains 43560 cubic feet. Rainfall is measured in depth over the surface and of late years the tendency has been to measure water for irrigation in the same way. One frequently hears it stated by practical irrigators that forty acres of spring wheat will require 40 miners' inches. But this statement conveys no definite idea as to the actual amount of water applied to the wheat field because the number of days the stream has been allowed to run on the field is not given. When, however, one states that 60 acre-feet were applied in two irrigations it shows that a certain definite volume of water was used during stated periods and that this volume was sufficient to have covered the 40 acre field to a depth of 1-½ feet.

One Irrigation.—How much water does it require for one irrigation? The amount will, of course, vary with a score or more of conditions. It may interest the reader to know that of 44 experiments



WEIR BOX IN USE.

made by this Station in different parts of Montana the average was 10 inches of water over the surface irrigated. This amount included all waste incurred on the field but did not include the losses in conveying the water from the natural channel to the borders of the field. The writer has found that with well made field laterals and skilled irrigators 6 inches of water will suffice to wet the soil to an average depth of one foot.

THE STANDARD UNIT AND THE ACRE-FOOT.—Irrigators frequently wish to convert running water into volumes. It may interest them to learn that a second-foot, or 40 miners' inches, flowing on an acre for one hour will cover it to a depth of one inch. If this stream is allowed to flow on an acre for a day it will cover it to a depth of two feet. This rule is not quite exact but may be used in general practice.

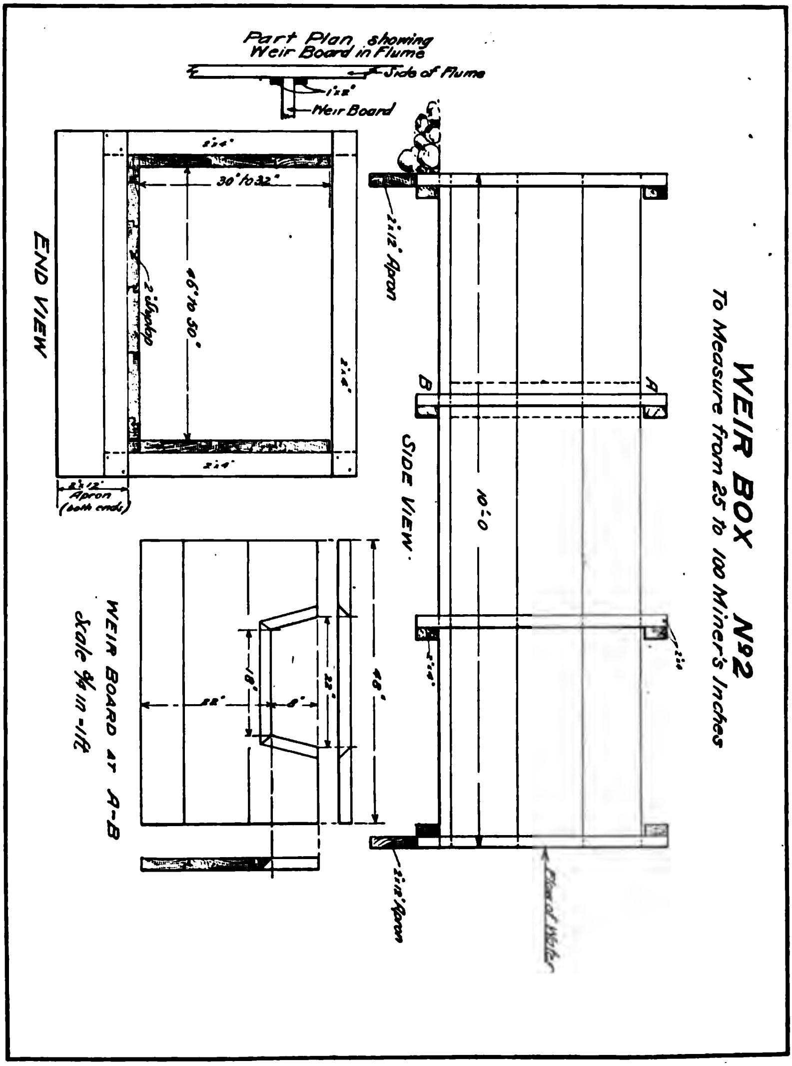
Irrigation Water Should be Measured.

Throughout the irrigated portions of Montana, 40 acres of land with 20 miners' inches of water will produce more than 80 acres without water. If this be true, and the statement would seem to be extremely conservative, a miners' inch of water apart from the cost of irrigation is equal in value to two acres of land. Still one finds that land is measured and mapped and when sold the purchaser is careful to see that the deed is valid and properly recorded. Whereas, in the case of irrigation water probably less than five per cent of the total volume used in the state has ever been measured.

The New Standard.

I am often asked to explain the new way of measuring water. The Montana legislature has prescribed no new method. It has merely adopted a standard unit in which all volumes of running water are hereafter to be expressed.

The same legislative assembly might have adopted the hundred weight as the standard unit for the sale of all grains and defined the bushel as equivalent to 50 pounds. Such a law would not have compelled farmers to use a particular make of scale or prevented them from using the bushel measure. The citizens of the state may measure


WEIR BOX No. 2
To Measure from 25 to 100 Miner's Inches
Part Plan showing Weir Board in Flume
Side of Flume
Weir Board
END VIEW
SIDE VIEW
WEIR BOARD AT A-B

Bill of Material for Weir Box No. 2.

No. of Pieces.	Actual Dimensions.	B. M. Feet.	Where Used.	Remarks.
	In. In. Ft. In			
6	2 x 12 x 10	120	Lining, Sides	Lumber, Rough.
4	2 x 12 x 10	80	Lining, Bottom	" "
1	2 x 6 x 10	10	Lining, Bottom	" "
8	2 x 4 x 5	26⅔	Sills and Ties	"
8	2 x 4 x 3 4	17¾	Posts	" "
2	2 x 12 x 5	20	Aprons	" "
2	2 x 12 x 4	16	Weir Board	Clear Lumber Surface.
1	2 x 10 x 4	6⅔	Weir Board	" " "
4	1 x 2 x 2 6	1⅔	Cleats, Sides	" " "
2	1 x 2 x 4	1⅓	Cleats, Bottom	" " "

7½ lbs. 20d wire nails.

½ lb. 6d wire nails.

irrigation water by any accurate method providing the results are expressed in cubic feet per second.

Current Meter Measuremants.—Of late years small insturments called current meters have been manufactured by several firms at prices ranging from $50 to $200 each. These meters indicate the velocity of the water in any open channel and the mean velocity when multiplied by the area of the section gives the discharge. This mode of measuring water has become quite popular owing to the ease and rapidity with which it can be done and also to the fact that fairly accurate results can be obtained without the use of flumes, boxes, or other devices.

Rating Flumes.—For occasional measurements the earthen channel of a ditch, or canal, answers all purposes but when more accurate and continuous measurements are desired rating flumes are usually constructed. These consist of wooden flumes as wide as the the water channel and from 8 to 24 feet in length placed to conform with the grade of the canal. The velocity of the water is found by a current meter and the depth of water is ofter recorded on a sheet attached to a self registering machine which needs attention only every seventh day.

Weir Boxes.—A weir box usally consists of a flume with the lower end enclosed. In the middle of the top of the lower end a notch is cut through which the water to be measured flows. Weirs require no instruments other then a foot rule, they are easily and cheaply made and measure flowing water within two per cent of accuracy when all the requisite conditions are fulfilled. Weir boxes as compared with miners' inch boxes are more accurate can be built for the same if not for less money and can be used to measure much larger volumes. The chief defects of this device are that the box often fflls with sediment which must be removed and that the water as it issues from the notch requires a drop of at least double the depth of water flowing through the notch.

Where to Place Farmers' Weirs.

For nearly half a century western irrigators have tried to devise a way by which water might be measured as it flows through a headgate.

They hoped to make one structure answer two purposes. In this they have failed for the reason that water is so much agitated and so irregular in flow as it passes through a headgate as to render it impossible to secure an accurate measurement. Of late years, measuring boxes have been placed at the most suitable points below the headgates and the latter control the stream while the former indicate the volumes. This rule applies to weirs. It is well to have a space of at least 50 ft. between the two structures and if a better site can be secured farther down the ditch the intervening distance may be increased to several hundred feet.

The weir boxes from No. 1 to No. 4 inclusive sketched in this bulletin are intended to be placed near the head gates of farmers' laterals which divert water from natural streams or canals. These boxes are designed to measure from 5 to 300 miners' inches and are intended for individual, and in the case of the larger sizes, for partnership use. Weir box No. 5 may be used at the head of a large lateral, or on one of the branches of a canal. It will measure sufficient water to supply the needs of from 5 to 15 farmers.

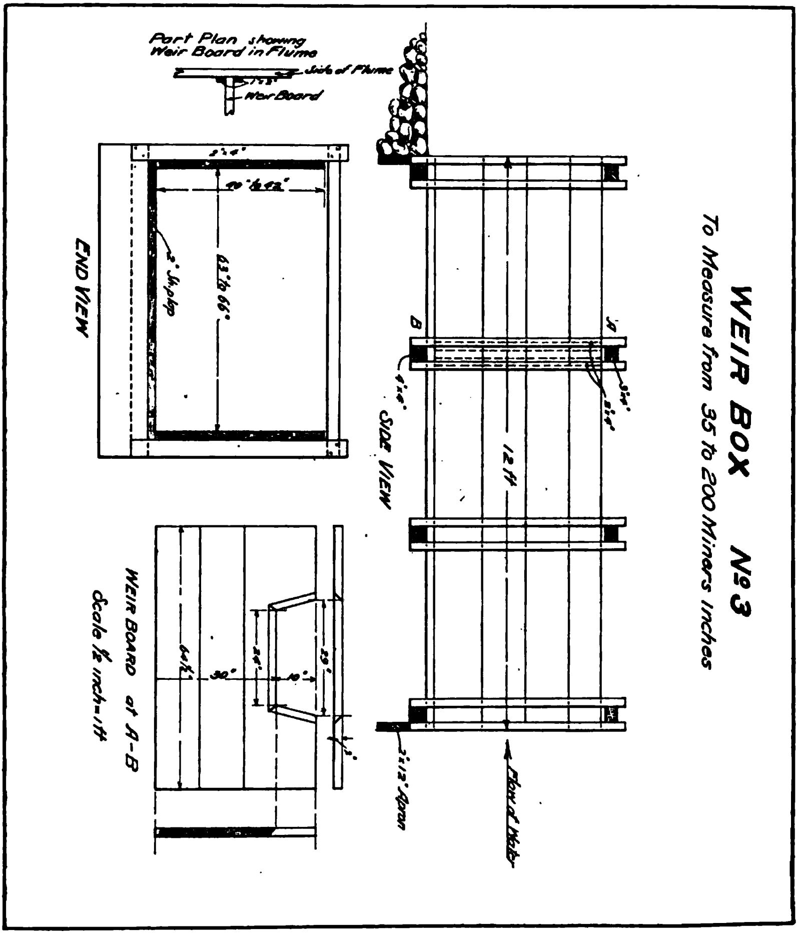
How to Place Weir Boxes.

Attention has already been called to the fact that weirs require a fall and with this in mind select for a site a part of the ditch that has a heavy grade.

The weir box should be placed on a level in both directions having the floor at the lower end on a level with the bottom of the ditch. The ditch banks above the weir box should be raised in order that the water may flow through the notch in the weir board. When the weir box is in position the apron is inserted in front and moist earth carefully tamped around the side. The ditch for a distance of 50 feet, or more, above the weir box should be regular and equal in depth and width to the inner dimensions of the box. Care must be taken that no water escapes either beneath or at the sides of the box.

In the case of the smaller sizes, the box may be built at the most convenient place, hauled to the site and then put in place.

It is usually more convenient to build it on the site. The

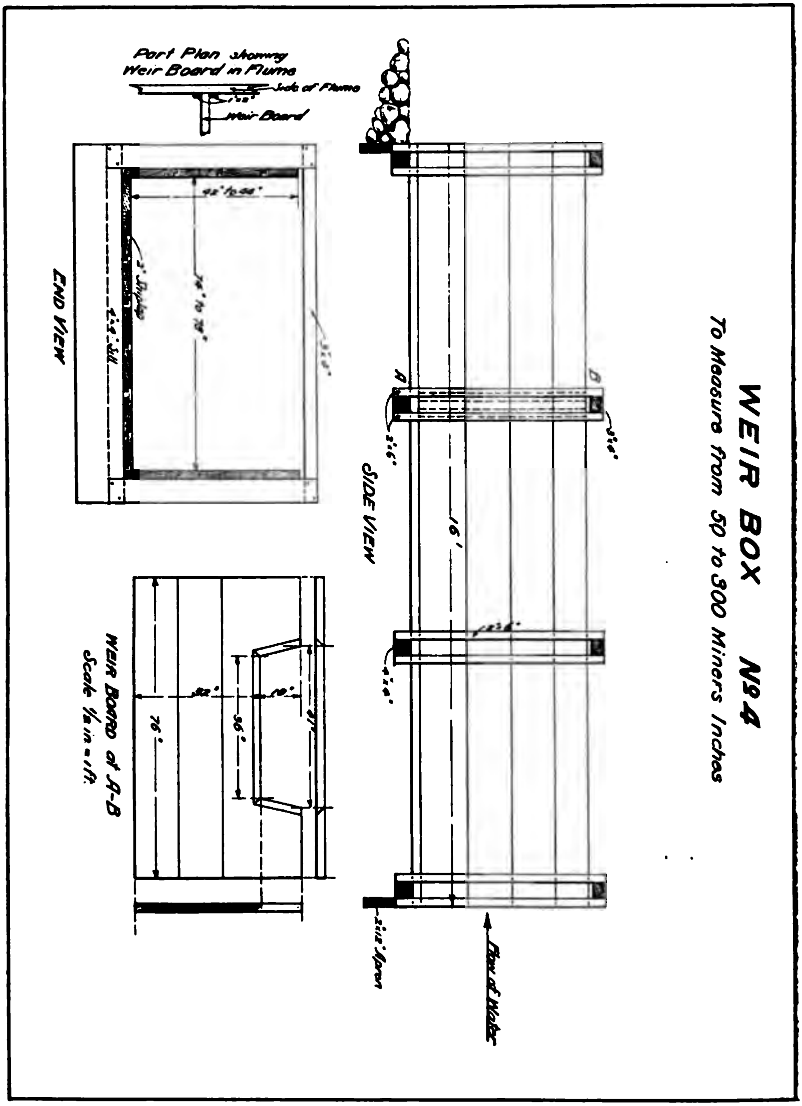

WEIR BOX No 3
To Measure from 35 to 200 Miners Inches
Part Plan showing Weir Board in Flume
Side of Flume
Weir Board
END VIEW
SIDE VIEW
12 ft
Flow of Water
2x12 Apron
WEIR BOARD at A-B
Scale 1/2 inch=1 ft

Bill of Material for Weir Box No. 3.

No. of Pieces.	Actual Dimensions.	B. M. Feet,	Where Used.	Remarks.
	In. In. Ft. In			
6	2 x 12 x 12	144	Lining, Sides	Lumber, Rough
2	2 x 10 x 12	40	Lining, Sides	" "
3	2 x 12 x 12	72	Lining, Bottom	" "
4	2 x 10 x 12	80	Lining, Bottom	" "
4	4 x 4 x 6 4	34	Sills.	" "
4	3 x 4 x 6 4	24	Ties.	" "
16	2 x 4 x 4 2	67	Posts.	" "
2	2 x 12 x 6 4	25⅓	Aprons.	" "
1	2 x 18 x 5 4½	16	Weir Board	Clear Lumber surfaced.
2	2 x 12 x 5 4½	21⅓	Weir Board	" " "
4	1 x 2 x 3 4	2¼	Cleats on Sides	" " "
2	1 x 2 x 5 4½	1½	Cleats, Bottom	" " "

11 lbs. 20d wire nails.

½ lb. 6d wire nails.

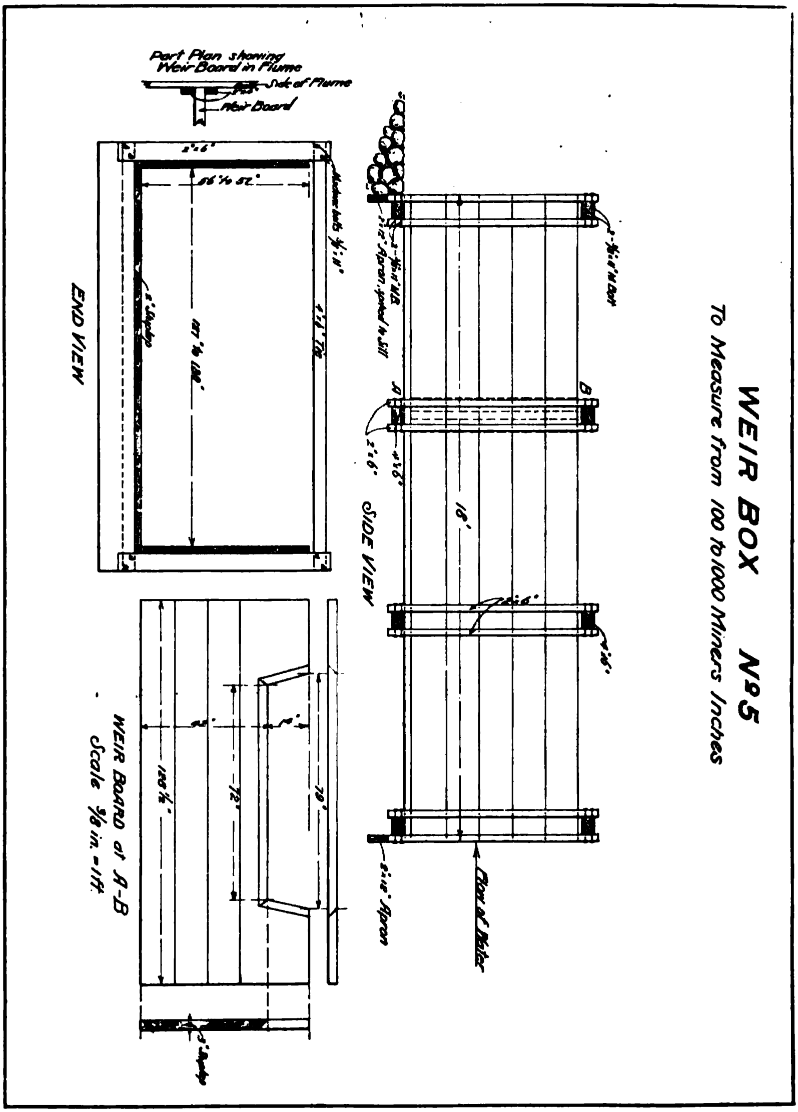

WEIR BOX No 4
To Measure from 50 to 300 Miners Inches
Part Plan showing Weir Board in Flume
Side of Flume
Weir Board
END VIEW
SIDE VIEW
WEIR BOARD at A-B
Scale 1/2 in = 1 ft.
Flow of Water

Bill of Material for Weir Box No. 4.

No. of Pieces.	Actual Dimensions.	B. M. Feet,	Where Used.	Remarks.
	In. In. Ft. In			
6	2 x 12 x 16	190	Lining, Sides	Lumber, Rough
2	2 x 10 x 16	53⅓	Lining, Sides	" "
4	2 x 12 x 16	128	Lining, Bottom	" "
4	2 x 10 x 16	106⅔	Lining, Bottom	" "
4	4 x 4 x 7 8	40 8-9	Sills.	" "
4	3 x 4 x 7 8	30⅔	Ties.	" "
16	2 x 6 x 4 4	69⅓	Posts.	" "
2	2 x 12 x 7 8	30⅔	Aprons.	" "
1	2 x 16 x 6 4	16 8-9	Weir Board	Clear Lumber surfaced.
2	2 x 14 x 6 4	29 5-9	Weir Board	" " "
4	1 x 2 x 2 6	1⅔	Cleats on Sides	" " "
2	1 x 2 x 6 4	2 1-9	Cleats, Bottom	" " "

12 lbs. 20d wire nails.

1 lb. 6d wire nails.


WEIR BOX No 5
To Measure from 100 to 1000 Miners Inches
Part Plan showing Weir Board in Flume
Side of Flume
Weir Board
END VIEW
SIDE VIEW
Flow of Water
WEIR BOARD at A-B
Scale 3/8 in. = 1 ft.

Bill of Material for Weir Box No. 5.

No. of Pieces.	Actual Dimensions.	B. M. Feet	Where Used.	Remarks.
	In. In. Ft. In			
10	2 x 12 x 18	360	Lining Sides.	Lumber, Rough.
12	2 x 12 x 18	432	Lining Bottom.	" "
8	4 x 6 x 12 ½	193	Sills and Ties.	" "
16	2 x 6 x 5 8	91	Posts.	" "
2	2 x 12 x 12 ½	48	Aprons.	" "
1	3 x 20 x 10 8½	53⅓	Weir Board.	Clear Lumber Surfaced.
3	3 x 14 x 10 8½	112	" "	" " "
4	2 x 4 x 2 6	6⅔	Cleats, sides.	" " "
2	2 x 4 x 11	14⅔	Cleats, bottom.	" " "

10 lbs. 20d wire nails.

1 lb. 6d wire nails.

32 ⅜ in. x 11 ins. Machine bolts.

frame work or yokes are first framed and put into position after which the flooring and sides are nailed on and last of all the weir board is inserted.

Weir Gauges.

When great accuracy is required the depth of water over the crest of the weir is found by means of an instrument called a Hooke Gauge. The farmer uses simpler if less accurate methods. When the weir box is placed, care should be taken to have the bottom of the notch, or crest, level. An ordinary carpenter's spirit level may be used for this purpose. When the crest is horizontal, one end of the spirit level is placed on the center of the crest and when level the other end will mark the point for the zero of the weir gauge. In rough work a nail may be driven part way into the side of the box, the top of the nail being level with the crest of the weir. A thin plate of brass is to be preferred to a nail. In other cases gauges are inserted on the sides of the flume and properly marked in tenths of feet or inches. At other times a post from 1 to 2 inches square is placed in the center of the box and several feet above the weir board. The top of this post is on a level with the crest.

Drawings of Weir Boxes.

The first sketch represents a weir box in use and is introduced for the purpose of conveying some idea of the manner of placing such boxes in a lateral, or ditch. The gauge post referred to in a former paragraph is shown beneath the second tie-beam. Measurements are made from the top of the post.

Weir Box No. 1—is designed to measure from a few miners' inches up to 40 miners' inches. The length of the weir notch is 12 inches.

Weir Box No. 2—will measure volumes from 25 to 100 miners' inches. If extreme accuracy is not required it will also measure from 1 to 25 miners' inches. The preceding statement applies to all the sketches introduced in this bulletin.

Weir Box No. 3—should be used for all streams that do not exceed 200 miners' inches.

Weir Box No.4—has a length of weir of 3 feet and will measure

quantities of water ranging from a few miners' inches to 300 miners' inches.

WEIR BOX No. 5—represents the kind of box to insert on main laterals which supply a number of individual shareholders. If it be desired to measure volumes larger then 1000 miners' inches the length of the weir may be incressed from 7 to 8, 9 or 10 feet. Any increase in the length of the weir should be followed by a like increase in the other parts of the box. On the other hand if the volume to be measured be less than 1000 miners' inches the length of the weir in No. 5 may be decreased to 5 or 4, feet decreasing the other parts in proportion.

Weir Tables.

TABLE No 1—was prepared by Mr. J. S. Baker, Instructor in Civil Engineering, assisted by Mr. W. B. Freeman. To accommodate the farmers who use for the most part a carpenter's rule or a square, the depths over the crest are given in inches and fractions of an inch. The discharges are given in Montana miners' inches and were computed to the nearest whole number from the formula. $Q - 3.3\frac{3}{8}$ L. H. $\frac{3}{2}$

TABLE No. 2—is inserted for the benefit of engineers and canal superintendents who use decimal parts of a foot instead of inches and fractions thereof. The discharges are expressed in cubic feet per second. This table is taken from Bulletin No. 86 of the Irrigation Investigation series of the Department of Agriculture and was computed by Mr. C. T. Johnston under the surpervision of Professor Elwood Mead.

How to Measure Water Over Weirs.

The method to follow can best be shown by examples. Let us suppose that a farmer has made and placed a box similar to the one shown in drawing No. 1. After turning in the water and allowing it some time to attain a uniform flow he proceeds to the weir box and with an ordinary rule measures the depth of water flowing through the weir notch. Bear in mind that this measurement is not made at the weir board but at the regular gauge whether it be a nail, brass plate, or post as described under that head. We will assume that the depth

as found by the rule is 3½ inches. Now by referring to Table 1 he follows down the first column until 3½ is reached. The weir used is one foot and under the column marked '1-foot weir' and opposite the figure 3½ already found he finds the number 21 which indicates the number of miner's inches flowing over a one foot weir when the depth of water is 3½ inches. If the depth had been 4 inches, the flow would have been 26 miners' inches; if 6 inches, 48 miners' inches and so on.

As a second example, let us suppose that Weir box No. 3 is put in place and the water turned on. The depth as measured is, say 4 inches. Now we search for figure 4 in the first column and then find the discharge in the column marked '2-foot weir' which is 52 miners' inches. If the depth had been 8 inches the discharge would have been 147 miners' inches thus showing that the discharge over weirs is not in proportion to the depth.

Acknowledgment.

It is fitting that we should express our indebtedness to Cesare Cippoletti, the celebrated Italian Engineer who has given to the world the Cippoletti Weir and to Director L. G. Carpenter of Colorado for introducing this weir into Western America. In the foregoing pages the writer has attempted to describe how Cippoletti weirs may be made and used by Western farmers.

I have also to acknowledge the assistance rendered by Professor Elwood Mead of the office of Experiment Stations, Washington, D. C.

Mr. K. C. Schaub, a former student of the writer, prepared the drawings.

TABLE I. Discharges of Farmers' Weirs of Different lengths, expressed in Montana Miners' Inches.

Depth of water on crest.	1 foot weir.	1½-ft. weir.	2-foot weir.	3-foot weir.	4-foot weir.	5-foot weir.	6 foot weir.	7-foot weir.	8-foot weir.	9-foot weir.	10-ft. weir.
Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.	Miner's Inches.
⅛	⅛	¼	5-16	7-16	9-16	11-16	⅞	1	1⅛	1¼	1 7-16
¼	⅜	⅝	¾	1 3-16	1 9-16	2	2 5-16	2¾	3⅛	3½	4
⅜	¾	1⅛	1½	2¼	3	3¾	4½	5¼	6	6¾	7½
½	1⅛	1¾	2¼	3½	4⅝	5¾	6⅞	8	9⅛	10⅜	11½
⅝	1½	2	3	5	6	8	10	11	13	14	16
¾	2	3	4	6	8	11	13	15	17	19	21
⅞	3	4	5	8	11	13	16	19	21	24	27
1	3	5	6	10	13	16	19	23	26	29	32
1⅛	4	6	8	12	15	19	23	27	31	35	39
1¼	5	7	9	14	18	23	27	32	36	41	45
1⅜	5	8	10	16	21	26	31	37	42	47	52
1½	6	9	12	18	24	30	36	42	48	54	60
1⅝	7	10	13	20	27	34	40	47	54	60	67
1¾	7	11	15	22	30	38	45	52	60	67	75
1⅞	8	12	17	25	33	42	50	58	67	75	83
2	9	14	18	27	37	46	55	64	73	83	92
2⅛	10	15	20	30	40	50	60	70	80	90	100
2¼	11	16	22	33	44	55	66	77	87	98	109
2⅜	12	18	24	36	47	59	71	83	95	107	119
2½	13	19	26	38	51	64	77	90	102	115	128
2⅝	14	21	28	41	55	69	83	97	110	124	138
2¾	15	22	30	44	59	74	89	103	118	133	148
2⅞	16	24	32	47	63	79	95	111	126	142	158
3	17	25	34	51	68	85	102	119	136	152	169
3⅛	18	26	36	54	72	90	108	125	143	161	179
3¼	19	28	38	57	76	95	114	133	152	171	190
3⅜	20	30	40	60	80	100	121	141	161	181	201
3½	21	32	42	64	85	106	127	149	169	191	212
3⅝	22	34	45	67	89	112	134	157	179	201	224

TABLE 1. Diecharges of Farmers' Weirs of Different lengths, expressed in Montana Miners' Inches.—CONTINUED.

Depth of water on crest.	1-foot weir.	1½-foot weir.	2-foot weir.	3-foot weir.	4-foot weir.	5-foot weir.	6-foot weir.	7-foot weir.	8-foot weir.	9-foot weir.	10-foot weir.
Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.
3¾	24	35	47	71	94	118	141	165	188	212	235
3⅞	25	37	49	74	99	124	148	173	198	222	247
4	26	39	52	78	104	130	155	181	207	233	259
4⅛	27	41	54	81	109	136	163	190	217	244	271
4¼	28	43	57	85	114	142	170	199	227	255	284
4⅜	30	44	59	89	119	148	178	207	237	267	296
4½	31	46	62	93	124	155	185	216	247	278	309
4⅝	32	48	64	97	129	161	193	226	258	290	322
4¾	34	50	67	101	134	167	201	235	268	302	335
4⅞	35	52	70	105	139	174	209	244	279	314	349
5	36	54	72	109	145	181	217	254	290	326	362
5⅛	38	56	75	113	150	188	225	263	301	338	376
5¼	39	58	78	117	156	195	234	273	312	350	390
5⅜	40	61	81	121	161	202	242	282	323	362	404
5½	42	63	84	125	167	209	251	292	334	376	418
5⅝	43	65	86	130	173	216	259	303	346	389	432
5¾	45	67	89	134	179	223	268	313	357	402	447
5⅞	46	69	92	138	185	231	277	323	369	415	461
6	48	71	95	143	190	238	286	333	381	429	476
6⅛	49	74	98	147	196	246	295	344	393	442	491
6¼	51	76	101	152	202	253	304	354	405	455	506
6⅜	52	78	104	156	209	261	313	365	417	469	521
6½	54	81	107	161	215	269	322	375	429	483	537
6⅝	55	83	110	166	221	276	331	387	442	497	552
6¾	57	85	114	170	227	284	341	398	454	511	568
6⅞	58	88	117	175	234	292	350	409	467	525	584
7	60	90	120	180	240	300	360	420	480	540	600
7⅛	62	92	123	185	246	308	370	431	493	554	616
7¼	63	95	126	190	253	316	379	443	506	569	632

TABLE 1. Discharges of Farmers' Weirs of Different lengths, expressed in Montana Miners' Inches.—CONTINUED.

Depth of water on crest.	1-foot weir.	1-½foot weir.	2-foot weir.	3-foot weir.	4-foot weir.	5-foot weir.	6-foot weir.	7-foot weir.	8-foot weir.	9-foot weir.	10-foot weir.
Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miness' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.
7⅜	65	97	130	195	260	324	389	454	519	584	649
7½	67	100	133	200	266	333	399	466	532	599	665
7⅝	68	102	136	205	273	341	409	477	546	614	682
7¾	70	105	140	210	280	349	419	489	559	629	699
7⅞	72	107	143	215	286	358	430	501	573	644	716
8	73	110	147	220	293	367	440	513	586	660	733
8⅛	75	113	150	225	300	375	450	525	600	675	750
8¼	77	115	154	230	307	384	461	537	614	691	768
8⅜	79	118	157	236	314	393	471	550	628	707	785
8½	80	120	161	241	321	401	482	562	642	722	803
8⅝	82	123	164	246	328	410	492	574	656	739	821
8¾	84	126	168	252	335	419	503	587	671	755	838
8⅞	86	128	171	257	343	428	514	599	685	771	856
9	87	131	175	262	350	437	525	612	700	788	875
9⅛	......	134	179	268	357	446	536	625	714	804	893
9¼	......	137	182	273	364	456	547	638	729	820	911
9⅜	.....	139	186	279	372	465	558	651	744	837	930
9½	......	142	190	285	379	474	569	664	759	854	949
9⅝	......	145	193	290	387	484	580	677	774	861	967
9¾	......	148	197	296	394	493	592	690	789	888	986
9⅞	......	151	201	302	402	503	603	704	804	905	1005
10	......	154	205	307	410	512	615	717	820	922	1024
10⅛	......	157	209	313	417	522	626	731	835	939	1044
10¼	......	159	213	319	425	532	638	744	850	957	1063
10⅜	......	162	217	325	433	541	650	758	866	974	1083
10½	......	165	220	331	441	551	661	771	882	992	1102
10⅝	......	......	224	337	449	561	673	785	898	1010	1122
10¾	......	......	228	342	457	571	685	799	913	1027	1142
10⅞	......	......	232	349	465	581	697	813	930	1046	1162

TABLE 1. Discharges of Farmers' Weirs of Different lengths, expressed in Montana Miners' Inches.—CONTINUED.

Depth of water on crest.	1-foot weir.	1¼-foot weir.	2-foot weir.	3-foot weir.	4-foot weir.	5-foot weir.	6-foot weir.	7-foot weir.	8-foot weir.	9-foot weir.	10-foot weir.
Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.
11	....	....	236	355	473	591	709	827	946	1064	1182
11⅛	....	....	240	361	481	601	721	841	962	1082	1202
11¼	....	....	244	367	489	611	733	856	978	1100	1222
11⅜	....	....	249	373	497	621	746	870	994	1119	1243
11½	...	....	253	379	505	632	758	884	1011	1137	1263
11⅝	....	....	257	385	514	642	770	899	1027	1156	1284
11¾	....	....	261	391	522	652	783	913	1044	1174	1305
11⅞	....	....	265	398	530	663	795	928	1060	1193	1326
12	....	...	269	404	539	673	808	943	1077	1212	1347
12⅛	....	....	....	410	547	684	821	958	1094	1231	1368
12¼	....	....	....	417	556	694	833	972	1111	1250	1389
12⅜	....	....	...	423	564	705	846	987	1128	1269	1410
12½	....	....	....	430	573	716	859	1002	1145	1289	1432
12⅝	....	....	....	436	582	726	872	1017	1162	1308	1454
12¾	....	....	....	442	590	737	885	1032	1180	1328	1475
12⅞	....	....	....	449	599	748	898	1048	1197	1348	1497
13	....	....	....	456	607	759	911	1063	1215	1368	1518
13⅛	....	....	....	462	616	770	924	1078	1232	1389	1541
13¼	....	....	....	469	625	781	938	1094	1250	1409	1563
13⅜	....	....	....	475	634	792	951	1109	1268	1429	1585
13½	....	....	....	482	643	803	964	1125	1286	1449	1607
13⅝	....	....	....	....	652	815	978	1140	1303	1469	1629
13¾	....	....	....	....	661	826	991	1156	1321	1489	1652
13⅞	....	....	....	....	670	837	1005	1172	1340	1509	1675
14	....	....	....	....	679	849	1019	1189	1359	1530	1699
14⅛	....	....	....	....	688	860	1032	1204	1376	1550	1721
14¼	....	....	....	....	697	871	1046	1220	1394	1570	1743
14⅜	....	....	....	....	706	883	1059	1236	1412	1590	1766
14½	....	....	....	....	715	894	1073	1252	1431	1610	1789

TABLE 1. Discharges of Farmers' Weirs of different lengths, expressed in Montana Miners' Inches.—CONTINUED.

Depth of water on crest.	1-foot weir.	1½-foot weir.	2-foot weir.	3-foot weir.	4-foot weir.	5-foot weir.	6-foot weir.	7-foot weir.	8-foot weir.	9-foot weir.	10-foot weir.
Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.	Miners' Inches.
14⅝	....	....	....	....	725	906	1087	1268	1449	1631	1812
14¾	....	....	....	....	734	918	1101	1285	1468	1652	1835
14⅞	....	....	....	....	743	929	1115	1301	1487	1673	1859
15	....	....	....	....	753	941	1129	1317	1506	1694	1882
15⅛	....	....	....	....	....	953	1143	1334	1524	1715	1906
15¼	....	....	....	....	....	965	1158	1351	1543	1736	1929
15⅜	....	....	....	....	....	977	1172	1368	1562	1757	1953
15½	....	....	....	....	....	989	1186	1385	1580	1778	1977
15⅝	....	....	....	....	....	1001	1201	1402	1600	1801	2001
15¾	....	....	....	....	....	1013	1215	1419	1620	1822	2025
15⅞	....	....	....	....	....	1025	1229	1437	1639	1844	2049
16	....	....	....	....	....	1037	1244	1455	1659	1866	2073
16⅛	....	....	....	....	....	1049	1259	1472	1678	1888	2098
16¼	....	....	....	....	....	1061	1273	1489	1698	1910	2122
16⅜	....	....	....	....	....	1073	1288	1506	1717	1932	2147
16½	....	....	....	....	....	1086	1303	1523	1737	1954	2171
16⅝	....	....	....	....	....	1098	1318	1539	1757	1976	2196
16¾	....	....	....	....	....	1110	1333	1556	1777	1999	2221
16⅞	....	....	....	....	....	1123	1348	1572	1797	2021	2246
17	...	....	....	....	....	1135	1363	1589	1817	2044	2271
17⅛	....	....	..	....	....	....	1378	1607	1837	2066	2296
17¼	....	....	....	....	....	....	1393	1625	1857	2089	2321
17⅜	....	....	....	....	....	....	1408	1642	1877	2112	2346
17½	....	....	....	....	....	....	1423	1660	1897	2134	2372
17⅝	....	....	....	....	....	....	1438	1678	1918	2157	2397
17¾	....	....	....	....	....	....	1454	1696	1938	2181	2423
17⅞	....	....	....	....	....	....	1469	1714	1959	2204	2448
18	....	....	....	....	....	....	1484	1732	1979	2226	2474

TABLE II.—Discharges of Cippoletti Weirs of different lengths, computed from the formula $Q—3.3\frac{3}{8}\ LH^{\frac{3}{2}}$

Depth of water on crest.	1-foot weir.	1½ foot weir.	2-foot weir.	3-foot weir.	4-foot weir.	5-foot weir.	6-foot weir.	7-foot weir.	8-foot weir.	9-foot weir.	10-foot weir.
Feet	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.
0.01	0.0034	0.0051	0.0067	0.0101	0.0135	0.0168	0.0202	0.0236	0.0269	0.0303	0.0337
.02	.0095	.0143	.0190	.0286	.0381	.0476	.0571	.0667	.0762	.0857	.0952
.03	.0175	.0262	.0350	.0525	.0700	.0875	.1050	.1225	.1400	.1574	.1749
.04	.0269	.0404	.0539	.0808	.1077	.1347	.1616	.1885	.2155	.2424	.2693
.05	.0376	.0565	.0753	.1129	.1506	.1882	.2258	.2635	.3011	.3388	.3764
.06	.0495	.0742	.0990	.1484	.1979	.2474	.2969	.3464	.3958	.4453	.4948
.07	.0624	.0935	.1247	.1871	.2494	.3118	.3741	.4365	.4988	.5612	.6235
.08	.0762	.1143	.1524	.2285	.3047	.3809	.4571	.5333	.6095	.6856	.7618
.09	.0909	.1364	.1818	.2727	.3636	.4545	.5454	.6363	.7272	.8181	.9090
.10	.1065	.1597	.2129	.3194	.4259	.5323	.6388	.7452	.8517	.9582	1.0646
.11	.1228	.1842	.2457	.3685	.4913	.6141	.7370	.8598	.9826	1.1054	1.2283
.12	.1399	.2099	.2799	.4198	.5598	.6997	.8397	.9796	1.1196	1.2595	1.3995
.13	.1578	.2367	.3156	.4734	.6312	.7890	.9468	1.1046	1.2624	1.4202	1.5780
.14	.1764	.2645	.3527	.5291	.7054	.8818	1.0581	1.2455	1.4108	1.5872	1.7336
.15	.1956	.2934	.3912	.5868	.7823	.9779	1.1735	1.3691	1.5647	1.7603	1.9559
.16	.2155	.3232	.4309	.6464	.8619	1.0773	1.2928	1.5083	1.7237	1.9392	2.1547
.17	.2360	.3540	.4729	.7079	.9439	1.1799	1.4159	1.6519	1.8878	2.1238	2.3598
.18	.2571	.3857	.5142	.7713	1.0284	1.2855	1.5426	1.7997	2.0568	2.3139	2.5710
.19	.2788	.4182	.5576	.8365	1.1153	1.3941	1.6729	1.9518	2.2306	2.5094	2.7882
.20	.3011	.4517	.6022	.9034	1.2045	1.5053	1.8068	2.1079	2.4090	2.7101	3.0112
.21	.3240	.4860	.6480	.9720	1.2960	1.6199	1.9439	2.2679	2.5919	2.9159	3.2399
.22	.3474	.5211	.6948	1.0422	1.3896	1.7370	2.0844	2.4318	2.7792	3.1266	3.4740
.23	.3714	.5570	.7427	1.1141	1.4854	1.8568	2.2281	2.5995	2.9709	3.3422	3.7136
.24	.3958	.5938	.7917	1.1875	1.5834	1.9792	2.3750	2.7709	3.1667	3.5625	3.9584
.25	.4208	.6312	.8417	1.2625	1.6833	2.1042	2.5250	2.9458	3.3666	3.7875	4.2083
.26	.4463	.6695	.8927	1.3390	1.7853	2.2317	2.6780	3.1243	3.5707	4.0170	4.4633
.27	.4723	.7085	.9447	1.4170	1.8893	2.3617	2.8340	3.3033	3.7787	4.2510	4.7233
.28	.4988	.7482	.9976	1.4964	1.9952	2.4941	2.9929	3.4917	3.9905	4.4893	4.9881
.29	.5258	.7887	1.0515	1.5773	2.1031	2.6289	3.1546	3.6804	4.2062	4.7319	5.2577
.30	.5532	.8298	1.1064	1.6596	2.2128	2.7660	3.3192	3.8724	4.4256	4.9788	5.5320
.31	.5811	.8716	1.1622	1.7433	2.3244	2.9054	3.4865	4.0676	4.6487	5.2298	5.8109
.32	.6094	.9141	1.2189	1.8283	2.4377	3.0472	3.6566	4.2660	4.8754	5.4849	6.0943
.33	.6382	.9573	1.2764	1.9147	2.5529	3.1911	3.8293	4.4675	5.1058	5.7440	6.3822
.34	.6674	1.0012	1.3349	2.0023	2.6698	3.3372	4.0047	4.6721	5.3396	6.0070	6.6745
.35	.6971	1.0457	1.3942	2.0913	2.7884	3.4856	4.1827	4.8798	5.5769	6.2740	6.9711
.36	.7272	1.0908	1.4544	2.1816	2.9088	3.6360	4.3632	5.0904	5.8176	6.5448	7.2720
.37	.7577	1.1366	1.5154	2.2731	3.0308	3.7885	4.5463	5.3040	6.0617	6.8194	7.5771
.38	.7886	1.1830	1.5773	2.3659	3.1545	3.9432	4.7318	5.5204	6.3091	7.0977	7.8863
.39	.8200	1.2300	1.6399	2.4599	3.2799	4.0998	4.9198	5.7398	6.5597	7.3797	8.1997
.40	.8517	1.2776	1.7034	2.5551	3.4068	4.2585	5.1102	5.9619	6.8137	7.6654	8.5171
.41	.8838	1.3258	1.7677	2.6515	3.5354	4.4192	5.3031	6.1869	7.0708	7.9546	8.8384
.42	.9164	1.3746	1.8328	2.7491	3.6655	4.5819	5.4983	6.4146	7.3310	8.2474	9.1638
.43	.9493	1.4239	1.8986	2.8479	3.7972	4.7465	5.6958	6.6451	7.5944	8.5437	9.4930
.44	.9826	1.4739	1.9652	2.9478	3.9304	4.9130	5.8956	6.8782	7.8608	8.8434	9.8261
.45	1.0163	1.5244	2.0326	3.0189	4.0652	5.0815	6.0978	7.1141	8.1303	9.1466	10.1629
.46	1.0504	1.5755	2.1007	3.1511	4.2014	5.2518	6.3021	7.3525	8.4029	9.4532	10.5036
.47	1.0848	1.6272	2.1696	3.2544	4.3392	5.4240	6.5088	7.5936	8.6783	9.7631	10.8479
.48	1.1196	1.6794	2.2392	3.3588	4.4784	5.5980	6.7178	7.8372	8.9567	10.0764	11.1960
.49	1.1548	1.7321	2.3095	3.4643	4.6191	5.7738	6.9286	8.0834	9.2381	10.3929	11.5477
.50	1.1903	1.7854	2.3806	3.5709	4.7612	5.9515	7.1418	8.3321	9.5224	10.7127	11.9030
.51	......	1.8393	2.4524	3.6785	4.9047	6.1309	7.3571	8.5833	9.8095	11.0356	12.2618
.52	......	1.8936	2.5248	3.7873	5.0497	6.3121	7.5745	8.8370	10.0994	11.3618	12.6242
.53	......	1.9485	2.5980	3.8970	5.1961	6.4951	7.7941	9.0931	10.3921	11.6911	12.9901
.54	......	2.0039	2.6719	4.0079	5.3438	6.6798	8.0157	9.3517	10.6876	12.0236	13.3595
.55	......	2.0598	2.7465	4.1197	5.4929	6.8662	8.2394	9.6126	10.9859	12.3591	13.7323
.56	......	2.1163	2.8217	4.2326	5.6434	7.0543	8.4651	9.8760	11.2868	12.6977	14.1085
.57	......	2.1732	2.8976	4.3464	5.7953	7.2441	8.6929	10.1417	11.5905	13.0393	14.4881
.58	......	2.2307	2.9742	4.4613	5.9484	7.4355	8.9226	10.4097	11.8969	13.3840	14.8711
.59	......	2.2886	3.0515	4.5772	6.1029	7.6287	9.1544	10.6801	12.2059	13.7613	15.2573
.60	......	2.3470	3.1294	4.6940	6.2587	7.8234	9.3881	10.9527	12.5174	14.0821	15.6468
.61	......	2.4059	3.2079	4.8119	6.4159	8.0198	9.6238	11.2278	12.8317	14.4357	16.0396

Table II—Discharges of Cippoletti Weirs of difierent lengths computed from the Formula Q—3.3$\frac{3}{8}$ LH$^{\frac{3}{2}}$—Continued.

Depth of water on crest.	1-foot weir.	1½-foot weir.	2-foot weir.	3-foot weir.	4-foot weir.	5-foot weir.	6-foot weir.	7-foot weir.	8-foot weir.	9-foot weir.	10-foot weir.
Feet.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per sec.	Cu. ft. per ces.	Cu. ft. per sec.	Cu. ft. per sec.
0.62	......	2.4654	3.2871	4.9307	6.5743	8.2178	9.8614	11.5050	13.1486	14.7921	16.4357
.63	......	2.5252	3.3670	5.0505	6.7340	8.4175	10.1009	11.7844	13.4679	15.1514	16.8349
.64	......	2.5856	3.4475	5.1712	6.8949	8.6187	10.3424	12.0661	13.7899	15.5136	17.2373
.65	......	2.6464	3.5286	5.2929	7.0572	8.8215	10.5857	12.3500	14.1143	15.8786	17.6429
.66	......	2.7077	3.6103	5.4155	7.2206	9.0258	10.8310	12.6361	14.4413	16.2465	18.0516
.67	......	2.7695	3.6927	5.5390	7.3854	9.2317	11.0781	12.9244	14.7707	16.6171	18.4634
.68	......	2.8317	3.7757	5.6635	7.5513	9.4392	11.3270	13.2148	15.1027	16.9905	18.8783
.69	......	2.8944	3.8593	5.7889	7.7185	9.6481	11.5778	13.5074	15.4370	17.3667	19.2963
.70	......	2.9576	3.9435	5.9152	7.8869	9.8586	11.8304	13.8021	15.7738	17.7456	19.7173
.71	......	3.0212	4.0283	6.0424	8.0565	10.0706	12.0848	14.0989	16.1130	18.1272	20.1413
.72	......	3.0852	4.1137	6.1705	8.2273	10.2842	12.3410	14.3978	16.4547	18.5115	20.5683
.73	......	3.1497	4.1997	6.2995	8.3993	10.4992	12.5990	14.6988	16.7989	18.8985	20.9983
.74	......	3.2147	4.2863	6.4294	8.5725	10.7156	12.8588	15.0019	17.1450	19.2881	21.4313
.75	......	3.2801	4.3734	6.5601	8.7469	10.9336	13.1203	15.3070	17.4937	19.6804	21.8671
.76	......	......	4.4612	6.6918	8.9224	11.1530	13.3836	15 6142	17.8447	20.0753	22.3059
.77	......	......	4.5495	6.8243	9.0991	11.3728	13.6486	15.9233	18.1981	20.4729	22.7476
.78	......	......	4.6384	6.9577	9.2769	11.5961	13.9153	16.2345	18.5538	20.8730	23.1922
.79	......	......	4.7279	7.0919	9.4559	11.8198	14.1838	16.5477	18.9117	21.2757	23.6396
.80	......	......	4.8180	7.2270	9.6360	12.0450	14.4539	16.8629	19.2719	21.6809	24.0899
.81	......	......	4.9086	7.3629	9.8172	12.2715	14.7258	17.1801	19.6344	22.0887	24.5430
.82	......	......	4.9998	7.4997	9.9996	12.4995	14.9993	17.4992	19.9991	22.4990	24.9989
.83	......	......	5.0915	7.6373	10.1830	12.7288	15 2746	17.8202	20.3661	22.9118	25.4576
.84	......	......	5.1838	7.7757	10.3676	12.9595	15.5514	18.1433	20.7352	23.3271	25.9191
.85	......	......	5.2767	7.9150	10.5533	13.1916	15.8300	18.4683	21.1066	23.7449	26.3833
.86	......	......	5.3700	8.0551	10.7401	13.4251	16.1101	18.7952	21.4802	24.1652	26.8502
.87	......	......	5.4640	7.1960	10.9280	13.6599	16.3919	19.1239	21.8559	24.5879	27.3199
.88	......	......	5.5585	8.3377	11.1169	13.8961	16.6754	19.4546	22.2338	25.0131	27.7923
.89	......	......	5.6535	8.4802	11.3069	14.1337	16.9604	19.7872	22.6139	25.4406	28.2674
.90	......	......	5.7490	8.6235	11.4980	14.3726	17.2470	20.1216	22.9961	25.8706	28.7451
.91	......	......	5.8451	8.7677	11.6902	14.6128	17.5353	20.4579	23.3804	26.3030	29.2255
.92	......	......	5.9417	8.9126	11.8834	14.8543	17.8251	20.7960	23.7669	26.7377	29.7086
.93	......	......	6.0389	9.0583	12.0777	15.0971	18.1166	21.1360	24.1554	27.1748	30.1943
.94	......	......	6.1365	9.2048	12.2730	15.3413	18.4096	21.4778	24.5461	27.6143	30.6826
.95	......	......	6.2347	9.3520	12.4694	15.5867	18.7041	21 8214	24.9388	28.0561	31.1735
.96	......	......	6.3334	9.5001	12.6668	15.8335	19.0002	22.1669	25.3336	28.5003	31.6670
.97	......	......	6.4326	9.6489	12.8652	16.0815	19.2979	22.5142	26.7305	28.9468	32.1631
.98	......	......	6.5323	9.7985	13.0647	16.3309	19.5970	22.8632	26.1294	29.3956	32.6617
.99	......	......	6.6326	9.9489	13.2652	16.5815	19.8978	23.2141	26.5303	29.8467	33.1629
1.00	......	......	6.7333	10.1000	13.4667	16.8333	20.2000	23.5667	26.9333	30.3000	33.6667
1.01	......	......	......	......	......	......	20.5038	23.9211	27.3384	30.7556	34.1729
1.02	......	......	......	......	......	......	20.8090	24,2772	27.7454	31.2135	34.6817
1.03	......	......	......	......	......	......	21.1158	24.6351	28.1544	31.6737	35,1930
1.04	......	......	......	......	......	......	21.4240	24.9947	28.5654	32.1361	35.7067
1.05	......	......	......	......	......	......	21.7338	25.3561	28.9784	32.6007	36.2230
1.06	......	......	......	......	......	......	22.0450	25.7192	29.3933	33.0675	36.7417
1.07	......	......	......	......	......	......	22.3577	26.0840	29.8103	33.5365	37.2628
1.08	......	......	......	......	......	......	22 6719	26.4505	30.2291	34.0078	37.7864
1.09	......	......	......	......	......	......	22.9875	26.8187	30.6499	34.4812	38.3124
1.10	......	......	......	......	......	......	23.3045	27.1886	31.0727	34.9568	38.8409
1.11	......	......	......	......	......	......	23.6230	27.5602	31.4974	35.4346	39.3717
1.12	......	......	......	......	......	......	23.9430	27.9335	31.9240	35.9145	39.9050
1.13	......	......	......	......	......	......	24.2644	28.3084	32.3525	36.3965	40.4406
1.14	......	......	......	......	......	......	24.5872	28.6850	32.7829	36.8808	40.9786
1.15	......	......	......	......	......	......	24.9114	29.0633	33.2152	37.3671	41.5190
1.16	......	......	......	......	......	......	25.2370	29.4432	33.6494	37.8556	42.0617
1.17	......	......	......	......	......	......	25.5641	29.8248	34.0854	38.3461	42.6068
1.18	......	......	......	......	......	......	25.8925	30.2079	34.5234	38.8388	43.1542
1.19	......	......	......	......	......	......	26.2224	30.5928	34.9631	39.3335	43.7039
1.20	......	......	......	......	......	......	26.5536	30.9792	35.4048	39.8304	44.2560
1.21	......	......	......	......	......	......	......	31.3672	35.8483	40.3293	44.8103
1.22	......	......	......	......	......	......	......	31.7569	36.2936	40.8303	45.3670
1.23	......	......	......	......	......	......	......	32.1481	36.7407	41.3333	45.9259

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BULLETIN NO. 35.

MONTANA AGRICULTURAL

Experiment Station

OF THE

AGRICULTURAL COLLEGE OF MONTANA.

Report of Feeding Tests.

BEEF CATTLE AND SHEEP.

I. Comparative Results from Feeding Lambs, 1-year Wethers, 2-year Wethers and Aged Ewes.

II. Fattening Steers with Different Quantities of Grain.

BOZEMAN, MONTANA, MAY 1, 1902.

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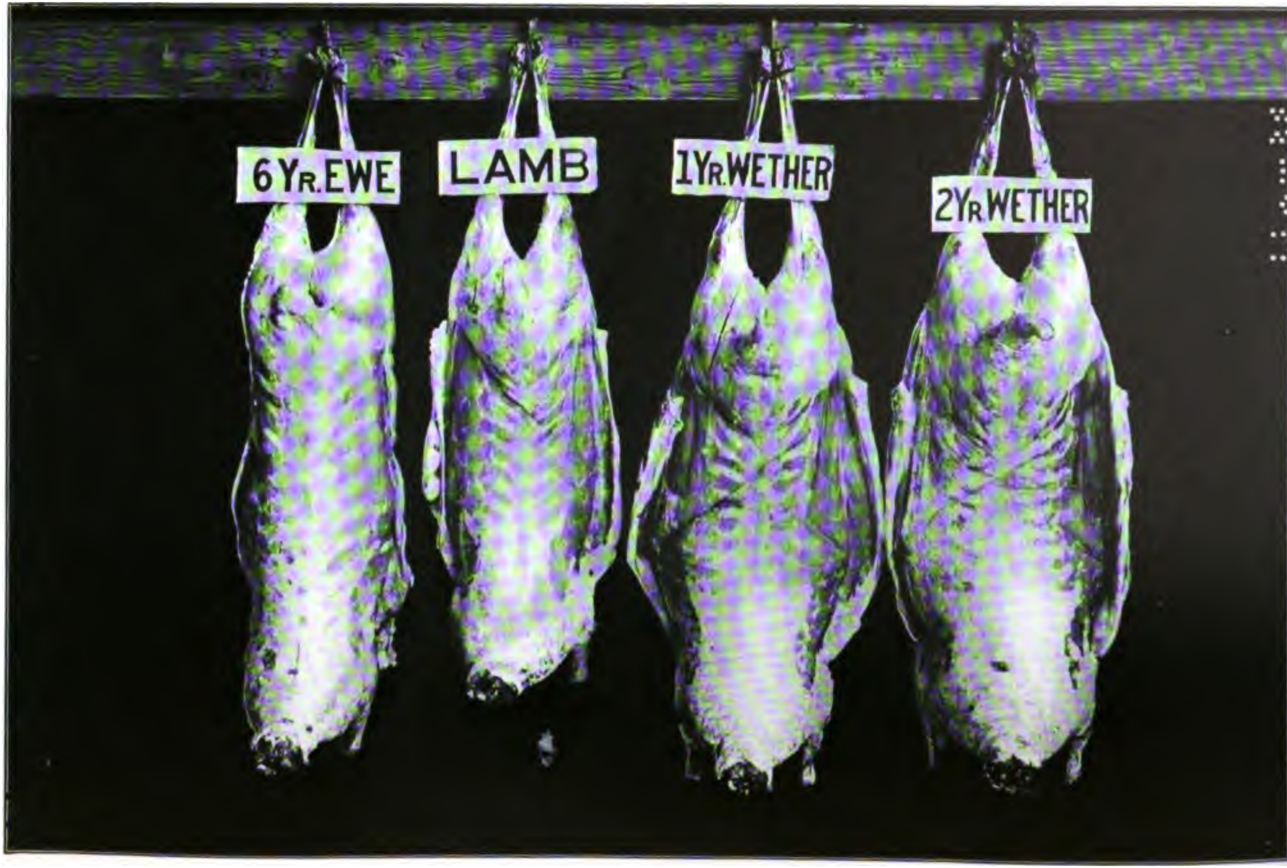
Bozeman, Montana.

Postoffice, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

MONTANA EXPERIMENT STATION,
Bozeman, Montana.

Notice.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.



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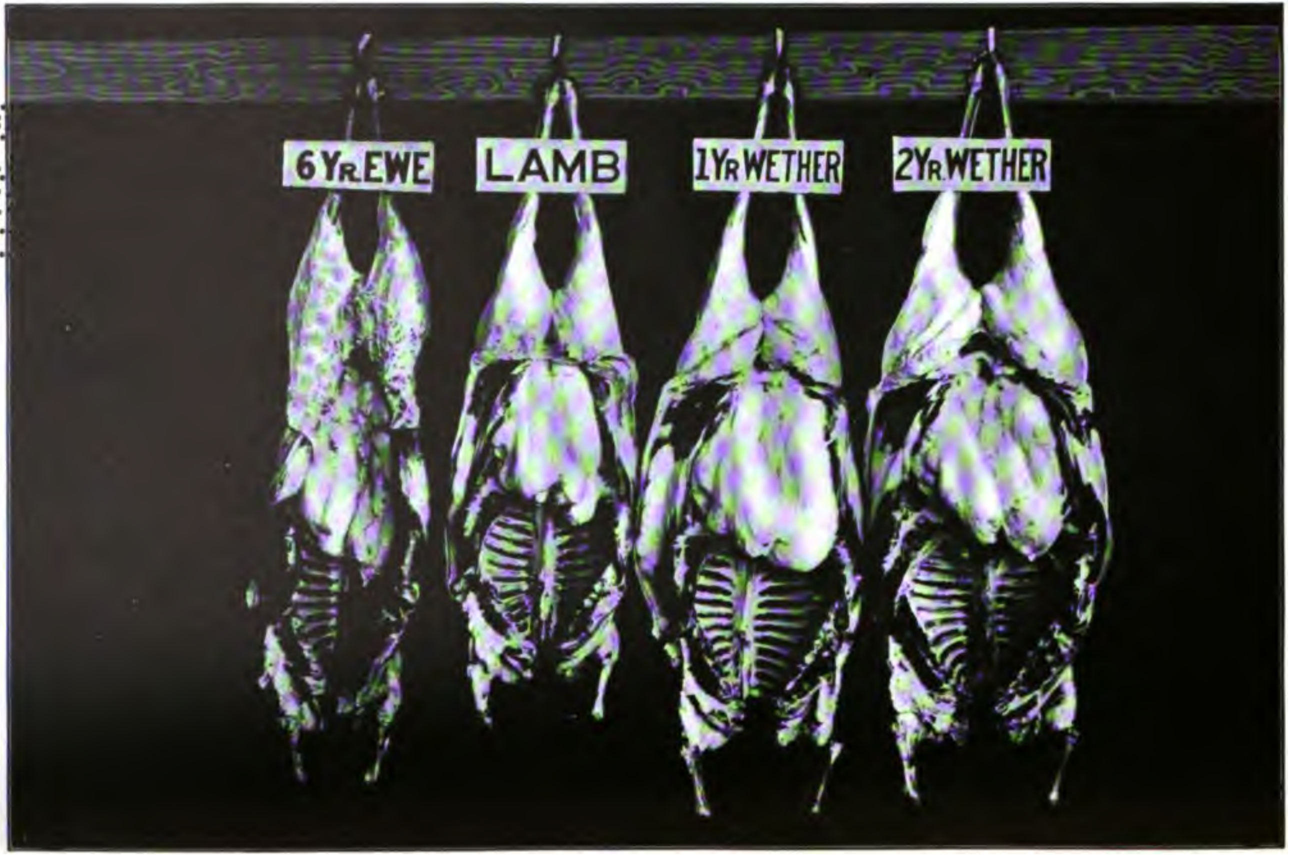

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Montana Experiment Station.

Bulletin No. 35. - - - - May 1902.

BY R. S. SHAW.

SHEEP FEEDING.

COMPARATIVE TESTS WITH LAMBS, YEARLING WETHERS, TWO-YEAR WETHERS, AND AGED EWES.

The primary object of this work during the past season was to secure data concerning the relative profits from feeding sheep of different ages for market. In procuring this data secondary determinations were made demonstrating many practical requirements and results in a comparative way along the following lines, viz:

(1) Amount of food required, per head, daily. (2) Relation of grain to coarse food for sheep of different ages. (3) Actual and percentage gains in live weight. (4) Air dry food necessary per pound increase. (5) Relative cost of food and increase. (6) Relative profits. (7) Report of slaughter test. (8) Shrinkage in transit.

This work was found to be necessary because of the rapidly increasing interest which is being manifested throughout the state in fitting sheep for market. Because of climatic conditions peculiar to the arid west and the kind and quality of its product, determinations even of the simplest and most practical character must be made

under these local conditions to supply the great demand for information. There has been a great demand for data relating to the suitability of sheep of different ages for the purpose stated. In the great majority of cases it is a matter of choice as to which class shall be used, for the feeding stocks are nearly all purchased by the farmer from the ranges when the feeding season begins.

For the purpose of these experiments, four lots consisting of wether lambs, yearling wethers, two-year wethers, and aged ewes were purchased for the Station, in Oct., 1902, by J. M. Robinson. The object in selection was to secure animals presenting uniformity in blood characters and the average of Montana range production. These sheep were purchased by the head, at the following prices: Lambs, $1.62; yearlings, $2.50; two-year-olds, $2.65; and aged ewes, $2.50. The average weights when feeding began were: Lambs, 62.9 lbs.; yearlings, 94.9 lbs.; two years, 115.7 lbs.; and ewes, 91.6 lbs. The sheep had the run of the farm for a few days before being put on feed. The feeding period began Nov. 22d, 1901, and closed February 17th, 1902, thus extending over a period of 88 days. The same kinds of food were used in each case and under similar conditions. The four lots were fed in yards, side by side, using racks for the hay and troughs for grain. The sheep had constant access to sheds and water which ran through the yards. Owing to the peculiarly favorable climatic conditions, the sheds were not used by the sheep more than a few days when the protection was badly needed.

Though it was the original intention to have fed lots of equal numbers of 55 each, this was not possible, owing to error in cutting the various bunches out from a large band. However, the data hereafter given shows the difference was not great and in no way affects the results. Some few average individuals from each lot were slaughtered at home for photographic purposes. The data throughout is based on the number which reached the Chicago market and upon which the slaughter test was reported.

Total Food Consumed and Cost of Same.

Feeding period began Nov. 22d, 1901 and ended Feb. 17, 1902, covering 88 days.

55 lambs consumed 9958 lbs. clover, @ $5.00 ton	$24.89
55 lambs consumed 3304 lbs. barley, @ 90c per cwt	29.73
Total	$54.62
51 1-yr. wethers consumed 16,960 lbs. clover, @ $5.00 per ton	$42.40
51 1-yr. wethers consumed 3073 lbs. barley, @ 90c per cwt	$27.65
Total	$70.05
53 2-yr. wethers consumed 18,905 lbs. clover, @ $5.00 per ton	$47.26
53 2-yr. wethers consumed 3195 lbs. barley, @ 90c per cwt	28.75
Total	$76.01
53 ewes consumed 10,904 lbs. clover, @ $5.00 per ton	$47.26
53 ewes consumed 3195 lbs. barley, @ 90c per cwt	28.75
Total	$56.01

The figures given above represent the actual amounts of food consumed, the percentage of waste having been deducted. While the ideal method is to feed without waste, under conditions such as these it must be taken into account in making accurate determinations. Where such close feeding is practiced that there is absolutely no waste, the gains will be somewhat affected as the ration in part becomes forced. The coarser and less edible the food the greater will be this loss. Under ordinary conditions, with the quality of foods which can be produced in Montana when properly cured, the loss should not exceed two or three per cent.

In this case the coarse food consisted of first and second crop clover hay. In general the quality was good, though a small amount had discolored in the stack. It had been cut in the first stages of bloom.

The grain food consisted exclusively of Chevalier barley and was fed unground in every case. While some question has arisen as

to whether better results would have been obtained had this grain been ground, there was no evidence to show that it was not perfectly masticated and digested. The ewe mouths were examined and found to be in fairly good condition with one exception only. A combination of grains was not used because of the fact that many of our feeders will of necessity be forced to use some one kind. Both wheat and oats have been used separately along with clover in previous tests. Good results have been secured from all three, with a slight gain in favor of oats, with wheat and barley about equal and very close to the oats in gains. The oats have proved to be far the most expensive food of the three, owing to local prices.

Food Consumed Per Head Per Day.

Lambs..........	Clover, 2.05 lbs.	Barley, .68 lbs.	Total, 2.73 lbs.
1-year Wethers...	Clover, 3.77 lbs.	Barley, .68 lbs.	Total, 4.45 lbs.
2-year Wethers...	Clover, 4.05 lbs.	Barley, .68 lbs.	Total, 4.73 lbs.
Aged Ewes......	Clover, 2.33 lbs.	Barley, .68 lbs.	Total, 3.01 lbs.

The figures given above represent the average daily consumption of hay and grain and also the average amount of total dry matter used per head throughout the 88 days. In the case of the lambs the amount of food actually consumed per head, per day, is a little less than we had expected. Under similar conditions, in previous tests, about three pounds has been required for a daily ration and the feeder should figure on no less than that amount in making estimates of the food required by large bands.

Relation of Grain to Coarse Food.

From the foregoing data we find the following relation to exist between the grain and the coarse food:

In Lamb ration......................24 per cent consisted of grain.
In 1-year Wether ration..............15 per cent consisted of grain.
In 2-year Wether ration..............14 per cent consisted of grain.
In Aged Ewe ration................22 per cent consisted of grain.

This relation of grain and coarse food (clover) was planned in order to give the four lots of different ages a uniform finish for the market. In the case of the lambs the largest percentage of grain was given, not as being necessary to produce a large increase in weight, but to give the carcass fatness; the tendency in the lamb being to an increase of a growthy nature rather than fat. The wethers, being practically mature sheep, were supplied a smaller percentage of grain as the increase in live weight is mostly fat. It is on this basis that we advocate the fattening of lambs only, when some grain can be used, and the selection of wethers where alfalfa or clover only are available. The larger ration of grain was furnished the ewes because of poor condition and vitiated digestive and assimilative powers.

Attention is especially called to the results secured in these experiments where grain forms less than one quarter of the ration. It is only through the use of legumes such as red clover, alsike and alfalfa, that such results can be secured. Where carbonaceous coarse foods such as native hays, corn fodder, sorghum, etc., are used, then the grain must form one half to two thirds of the ration in order to secure equivalent gains.

Weights and Increase in 88 Days from Food Fed.

VARIOUS LOTS.	Weight Nov. 22d, 1902	Average	Weight Feb. 17, 1902	Average	Total Gain	Gain Per Head	Gain Per Month	Percentage of Increase
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	per ct.
55 Lambs	3459	62.9	4764	86.6	1305	23.7	8.08	37.7
51 1-year Wethers	4840	94.9	6040	118.4	1200	23.5	8.01	24.7
53 2-year Wethers	6133	115.7	7420	140.	1287	24.3	8.28	20.9
53 Aged Ewes	4858	91.6	5684	107.2	826	15.6	5.31	17.

The weights above given were neither secured from the animals under full feed nor yet under a shrinkage. The practice followed was to weigh from eight to nine hours after the morning feed. The weights were taken every two weeks but owing to the uniformity in these the final results only are reported. Attention is particularly called to the column above giving the percentage increase in live weight. With the exception of the ewes the gains per head for 88 days, as well as the gains per month, appear to be quite similar, and until presented in a way in which comparison is made more clear, the differences are not so manifest. The percentage of increase added to the original live weight was as follows: Lambs 37 per cent, 1-yr. wethers 24.7 per cent, 2-yr. wethers 20.9 per cent, and aged ewes 17 per cent.

Amount of Air Dry Food Consumed Per Pound Increase Including Maintenance.

Lambs..............Dry food consumed per pound gain, 10.16 lbs.
1-yr. Wethers........Dry food consumed per pound gain, 16.6 lbs.
2-yr. Wethers........Dry food consumed per pound gain, 17.1 lbs.
Aged Ewes..........Dry food consumed per pound gain, 17.5 lbs.

Owing to the small proportion of grain in the ration, viz.: .68 lb per head per day, the total amount of dry food required to produce a pound of gain is larger than where more grain is used. In previous experiments where about one pound of grain was used in the daily ration for lambs, along with clover, only 8.75 pounds of dry matter was required to produce a pound of increase.

In the above, the comparison between the lambs and ewes is made on an equal basis, but in the case of the wethers the proportion of hay is greater, consequently, the amounts given for them are a little high in comparison.

Relative Cost of Production.

Lambs.........Cost per 100 pounds increase in live weight, $4.18
1-yr. Wethers.....Cost per 100 pounds increase in live weight, 5.83
2-yr. Wethers.....Cost per 100 pounds increase in live weight, 5.90
Aged Ewes......Cost per 100 pounds increase in live weight, 6.78

The cost of production is a matter which of course materially affects the financial results. In the figures given above we find one more striking illustration of the fact that the younger the animal the less will be the cost of increase in live weight produced by it. And then in referring to the sale statement, we find the value thereby given is in about an inverse proportion to the age of the animals.

Attention is called here to the fact that an accurate comparison can only be made between the lambs and ewes, as about the same relationshlp existed in these two cases between the grain and coarse food. The lamb and ewe rations contained 24 and 22 per cent of grain respectively, while the wether rations contained only 14 and 15 per cent of grain. As the grain, however, was worth about 1 cent per pound and the clover 1/4 cent per pound, this difference in price would about even things up in the case of the wethers.

Per Capita Cost of Food Consumed.

Lambs, value of food consumed per head during 88 days, $ .99
1-yr. Wethers, value of food consumed per head during 88 days, 1.37
2-yr. Wethers, value of food consumed per head during 88 days, 1.43
Aged Ewes..value of food consumed per head during 88 days, 1.05

Financial Statement.

LAMBS.

Nov. 22, 1901, To 55 lambs at $1.62½ per head, ...	$ 89.37	
Feb. 17, 1902, To cost of feed for 88 days	54.62	
Feb. 25, 1902, To cost of shipping.................	42.96	
Feb. 25, 1902, By 55 lambs, 4340 lbs. at $6.50 per cwt.		$282.10
Feb. 25, 1902, To net profit......................	95.15	
	$282.10	$282.10

1-YEAR WETHERS.

Nov. 22, 1901, To 51 1-yr. wethers at $2.50 per head...	$127.50	
Feb. 17, 1902, To cost of feed for 88 days..........	70.05	
Feb. 25, 1902, To cost of shipping.................	54.84	
Feb. 25, 1902, By 51 wethers, 5540 lbs. at $5.85 cwt.		$324.09
Feb. 25, 1902, To net profit......................	71.70	
	$324.09	$324.09

2-YEAR WETHERS.

Nov. 22, 1901, To 53 2-yr. wethers at $2.65 per head..	$140.45	
Feb. 17, 1902, To cost of food for 88 days..........	76.01	
Feb. 25, 1902, To cost of shipping.................	67.30	
Feb. 25, 1902, By 53 wethers, 6800 lbs. at $5.40 cwt.		$367.20
Feb. 25, 1902, To net profit......................	83.44	
	$367.20	$367.20

AGED EWES.

Nov. 22, 1901, To 53 ewes at $2.50 per head........	$132.50	
Feb. 17, 1902, To cost of food for 88 days..........	56.01	
Feb. 25, 1902, To cost of shipping.................	49.89	
Feb. 25, 1902, By 53 ewes, 5040 lbs. at $4.75 cwt.		$239.40
Feb. 25, 1902, To net profit......................	1.00	
	$239.40	$239.40

In determining the relative profits from each of the four lots it was necessary to divide the expense of shipping, consisting of frieght charges, feed, commission, etc. This was done on the basis of weights, as the two most important features of expense, freight and feed, are in proportion to weight. Owing to stop-overs for feeding the expenses in this case were considerably above the average, which prevents our profits from being still larger.

Relative Profits From the Four Lots.

55 lambs gave a net profit of $95.15 or $1.73 per head.

51 1-year wethers gave a net profit of $71.70 or $1.40 per head.

53 2-year wethers gave a net profit of $83.44 or $1.57 per head.

53 aged ewes gave a net profit of $1.00, or 1.8 cents per head.

The figures given above do not represent the total profits. The hay was charged up at $5 per ton and grain at 90 cents per cwt. Both prices being above cost of production, a secondary profit occurs here which is not considered in the data. It is the custom in all feeding experiments to offset the cost of labor by the value of the manue left on the farm to maintain fertility. The greater profit from the two-year wethers as compared with the yearlings is due to the purchase prices. While 94.9 lb. yearlings cost $2.50, 115.7 lb. two year olds were purchased at $2.65.

Report of Slaughter Test, by Swift & Co. of Chicago.

55 lambs, average 79 lbs., $6.50, dress 54.2 per cent.

51 1-year wethers, average 108 lbs., $5.85, dress 52.9 per cent.

53 2-year wethers, average 128 lbs., $5.40, dress 53.5 per cent.

53 ewes, average 95 lbs., $4.75, dress 50.6 per cent.

"We consider all of these sheep and lambs a useful class of stock, not too fat, and they dress about 2 per cent above the average coming to the Chicago market at the present time."

"The percentage of dressed weight is figured on a basis of actual weight immediately after killing, shrunk 3 per cent, which is about what the mutton will shrink after hanging over night."

Shrinkage.

This was determined from weights when sheep were taken off feed on February 17th and the weights given in sale bill from Chicago February 24th.

Lambs shrunk 7.6 lbs. or 8.7 per cent.
1-year wethers shrunk 10.4 lbs. or 8.7 per cent.
2-year wethers shrunk 12. lbs. or 8.5 per cent.
Aged ewes shrunk 12.2 lbs. or 11.3 per cent.

For the benefit of those interested in shipping and that the figures relating to shrinkage may be better understood, we give the following detailed account of the trip, as provided by Mr. Robinson, who accompanied the shipment. The sheep left Bozeman about noon of the 18th of February and arrived at Mandan on the 19th at 3 p. m., where they were fed hay only. Left Mandan at noon on 20th and arrived in St. Paul at 5:30 a. m. 21st, where the sheep received a grain ration with the hay. Left St. Paul at noon 23d and reached Chicago at 4 a. m. 24th. The sheep were weighed and sold at 10 a. m. The time actually in transit was three days and four nights. Mr Robinson suggests that it would be of material interest to shippers to stop and feed at a point nearer Chicago.

Cost of Marketing.

This includes all expense of shipping, such as transportation, yardage, feed, commission, etc. As before stated, these expenses were divided in proportion to the weights of the four lots in determining the relative profits from each, on the basis that freight tariff is the same per pound and that the food consumed while in transit is in proportion to the weight of the animals. On this basis, we get the following relative cost of marketing:

55 lambs, weight 4340 lbs., cost of marketing $42.96, cost per head, $ .78.

51 1-year wethers, weight 5540 lbs., cost of marketing $54.84, cost per head, $1.07.

53 2-year wethers, weight 6800 lbs., cost of marketing $67.30, cost per head, $1.27.

53 ewes, weight 5040 lbs., cost of marketing $49.89, cost per head $ .94.

Average cost per head, $1.01.

The shipper will be safe in accepting the above data as regards the cost of marketing, as in this instance, the expenses are a trifle above normal. This is due to the necessity of holding over in St. Paul for two and one-half days in order to complete the trip with a special stock train. In this case the expense of marketing was practically one cent per pound with the various classes.

Summary of Facts.

(1). The feeding of lambs for market is more profitable than wethers or ewes, providing the ration is so adjusted as to give their rapid increase a finish.

(2). Owing to the growthy tendency of the lamb, its ration must possess more fat producing material than the mature sheep.

(3). Where grain is not available, the mature wether, though making a smaller proportionate increase, will fatten more readily than the lamb on clover or alfalfa alone. The use of from one half to three quarters of a pound of grain, along with clover or alfalfa, throughout a period of from 70 to 90 days, is necessary to produce a proper finish for shipping.

(4). For lambs, yearling and two year wethers and aged ewes, the following amounts of food were consumed per head, per day, viz: 2.73 lbs., 4.45 lbs., 4.73 lbs., and 3.01 lbs. Attention is called to the fact that the amount consumed by the lambs is small, due to their light weights.

(5). In order to secure an even finish, the grain fed formed the following percentages of the ration, viz: For lambs 24 per cent., 1-year wethers 15 per cent , 2-year wethers 14 per cent., aged ewes 22 per cent.

(6). The relative increase in live weight is represented in the following percentages: For lambs 37.7 per cent. 1-year wethers 24.7 per cent, 2-year wethers 20.9 per cent, ewes 17 per cent.

(7). The following amounts of air dry food were required for maintenance and per pound increase, viz: Lambs 10.16 lbs., 1-year wethers 16.6 lbs., 2-year wethers 17 lbs. and ewes 17.5 lbs. As here-

tofore explained, this comparison applies properly to lambs and ewes only, owing to difference in the proportionate make up of the wether rations.

(8). Relative costs of production per 100 lbs. increase: Lambs $4.18, 1-year wethers $5.83, 2-year wethers $5.90, aged ewes $6.78.

(9). Per capita cost of food consumed during 88 days: Lambs 99c, 1-year wethers $1.37, 2-year wethers $1.43, ewes $1.05.

(10). Relative profits per capita from the four lots: Lambs $1.73, 1-year wethers $1.40, 2-year wethers $1.57, aged ewes 1.8 cents.

(11). Percentage of dressed carcass after deducting 3 per cent from same: Lambs 54.2 per cent, 1-year wethers 52.9 per cent, 2-year wethers 53.6 per cent, ewes 50.6 per cent.

(12). Shrinkage in transit, covering 1400 miles, determined from weights while on full feed and those of sale: Lambs 8.7 per cent., 1-year wethers 8.7 per cent, 2-year wethers 8.5 per cent., ewes 11.3 per cent.

(13). The suggestion, resulting from personal experience, is offered to the effect that sheep will withstand shipping better if kept on a limited allowance during transit, rather than on full feed. But that feed and rest are essential toward the close of trip.

(14). The total net profit from the car of mixed sheep was $251.29.

(15). Even though the cost of marketing is a large item, still, this is offset by cheap feeders and an abundance of cheap food of good quality which renders the feeding business a profitable industry.

PART II.

CATTLE FEEDING.

The objects sought in this work were to determine the relative results from feeding light, medium and heavy grain rations in conjunction with legumes for fattening purposes. Though similar work has been done along these same lines in other portions of the country, still, it was thought best to repeat it here owing to the marked difference in the quality of Montana grown food stuffs. Figures were also sought to support previous assertions of the fact that only a minimum amount of grain is necessary along with our legumes to produce a good quality of beef or mutton.

For the purpose of this experiment twenty-two 2-year old steers were purchased by Mr. Jos. Kountz. These animals were grades showing Shorthorn blood and were growthy but thin and in a condition to put on flesh rapidly as the figures show. They were about the average of range production.

The feeding period was divided into three parts, viz: preliminary test and final. The preliminary period of twenty four days extending from Dec. 9th, 1901 to Jan. 3d, 1902, was necessary in order to get the animals all under full feed after the operation of dehorning. The trial test proper was a short one extending from Jan. 3d to Mar. 28th, a period of eighty five days. In the final the animals were merely kept on feed till April 12th when they were disposed of.

The feeding was done in open yards with sheds provided for shelter and with constant access to water. The sheds were used at night almost continually while in the case of the sheep very seldom. In general the weather was a little too mild during the test proper. The yards thawed out nearly every day. The best conditions seem to be when the thermometer does not rise above 32 degrees during the day.

Food Consumed by Three Lots and Cost of Same.

LOT I. 7 STEERS.

Clover fed Jan. 2d to Mar. 28th, 11,540 lbs. at $5 per ton.....$28.85
Barley meal fed Jan. 2d to Mar 28th, 2975 lbs. at 90c per cwt. 26.77
Total..............................$55.62

LOT II. 7 STEERS.

Clover fed Jan. 2d to Mar. 28th, 11,560 lbs. at $5 per ton.....$28.95
Barley meal fed Jan. 2d to Mar. 28th, 4008 lbs. at 90c per cwt. 36.07
Total..............................$65.02

LOT III. 8 STEERS.

Clover fed Jan. 2d to Mar. 28th, 13,500 lbs. at $5 per ton.....$33.75
Barley fed Jan. 2d to Mar. 28th, 6057 lbs. at 90c per cwt....$54.51
Total..............................$88.26

The clover hay was fed twice each day in racks so constructed that there was no waste. The barley was ground and the meal fed in flat troughs raised about three feet above the ground.

Average Amount of Food Consumed per Day.

Lot I. Clover consumed per head per day..............19.3 lbs.
Lot I. Barley meal consumed per head, per day......... 5. lbs.
Total..........................24.3 lbs.
Lot II. Clover consumed per head per day..............19.4 lbs.
Lot II. Barley meal consumed per head per day........ 6.73 lbs.
Total..........................26.13 lbs.
Lot III. Clover consumed per head per day............19.8 lbs.
Lot III. Barley meal consumed per head per day....... 8.9 lbs.
Total..........................28.7 lbs.

Attention is called to the fact that the amounts of clover consumed daily are about the same for the three lots, even though the amount of grain increased from lot I. up. The fact that more food

was required even where more grain was fed is due to the greater weights of lots II. and III. The division was made on a basis of quality rather than weight. The aim being to have the steers of the different lots as even in quality as possible.

Preliminary Weights and Effect of Dehorning.

22 steers, weight Dec. 9th, 1901, 22185 lbs., average 1008.
22 steers, weight Jan. 2d, 1902, 23170 lbs., average 1053.

Average gain during period of twenty four days 45 lbs.
Gain per head per day during period of 24 days, 1.87 lbs.
Gain per head per day during period of 85 days, 2.27 lbs.

The figures relating to weights secured during the preliminary period show that dehorning had little effect on the steers. The average daily gains are some smaller, which is partly due to the fact that less grain was fed than in the next period. These animals fed heartily immediately after the operation.

Test Weights, for 85 Day Period.

VARIOUS LOTS.	Weight Jan. 2d, 1902.	Average...........	Weight Mar. 28, 1902.	Average...........	Total Increase..........	Increase per head.......	Increase per day.......	Per cent increase......
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Per ct.
Lot I, 7 Steers ..	6850	978.5	8240	1177	1390	198.5	2.33	20.2
Lot II, 7 Steers...	7240	1034.3	8590	1227	1350	192.8	2.26	18.6
Lot III, 8 Steers..	9080	1135.	10600	1325	1520	190.	2.23	16.7

Food Per Head Per Day per 100 lbs. Live Weight.

Pen I. Average 1077 lbs. barley per cwt. .46 lbs. clover 1.79 lbs.
Pen II. Average 1130 lbs. barley per cwt. .59 lbs. clover 1.71 lbs.
Pen III. Average 1230 lbs. barley per cwt. .72 lbs. clover 1.61 lbs.

The results indicate that where legumes are used as roughage, not more than one-half pound of meal per 100 lbs. live weight, per day, is necessary to produce satisfactory gains and at the smallest cost. This is true only, however, of perfectly cured and preserved clover and alfalfa, such as are produced in the arid west.

Solid Food per lb. Increase.

Lot. I. Food per pound increase, 10.4 lbs.
Lot. II. Food per pound increase, 11.5 lbs.
Lot. III. Food per pound increase, 12.9 lbs.

Attention is called to the fact that these figures include maintenance during the time each pound was being produced and that owing to differences in live weight these figures would be affected accordingly.

Cost Per Pound Increase.

Pen No. I. Cost per cwt. increase, $4.00
Pen No. II. Cost per cwt. increase, $4.81
Pen No. III. Cost per cwt. increase, $5.80

Financial Statement.

Jan. 2d, 1902—By clover, first period, 14,295 lbs. at $5 per ton..	$ 35.73
Jan. 2d, 1902—By barley, first period, 1141 lbs. at 90c cwt....	10.26
Mar. 28, 1902—By clover, test period, 36,600 lbs. at $5 per ton.	91.50
Mar. 28, 1902—By barley, test period, 13,040 lbs. at 90c cwt...	117.35
Apr. 12, 1902—By clover, third period, 6435 lbs. at $5 per ton..	16.08
Apr. 12, 1902—By barley, third period, 2267 lbs. at 90c cwt...	20.40
Dec. 9, 1901—By 20 steers, at $33.00 per head..............	660.00
Dec. 9, 1901—By 2 steers, at $34.00 per head...............	68.00
Apr. 15, 1902—By net profit on 22 steers....................	168.68
	$1188.00
Apr. 15, 1902, To 22 steers at $54.00 per head..............	$1188.00
Net profit per head.......................................	$7.66

This sum does not represent the complete profit from each animal as the food is charged up at local market prices and is much above cost.

The carload of steers was purchased by Mr. Jno. Kiefer of Bozeman, by whom the carcasses shown in the illustrations were prepared for photographing.

Conclusions.

(1). Because of the quality of Montana grown food products and the favorable climatic conditions during the winter feeding period, maximum returns can be secured from a minimum amount of food.

(2). That in fattening steers, when alfalfa and clover are used, not more than one-half pound of grain to the hundred weight of live weight is necessary to produce the most satisfactory results.

(3). Contrary to local impressions, some grain must be used throughout a period not less than one hundred and twenty days in order to get a good finish.

Acknowledgments.

The report of slaughter test so kindly furnished by the Messrs. Swift & Co. of Chicago has been of great service, not only because of the information furnished by it, but also from additional data which could only be secured through its aid.

Much of the success of this work is due Mr. G. M. Fuller under whose supervision the experiments were conducted.

BULLETIN NO. 36.

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

FORAGE CONDITIONS

OF CENTRAL MONTANA.

Bozeman, Montana, June, 1902.

REPUBLICAN.
Bozeman, Montana,
1902.

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MONTANA EXPERIMENT STATION.

Bozeman, Montana.

NOTICE.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

BULLETIN NO. 36. - - - JUNE, 1902.

S. FORTIER,

Director Montana Agricultural Experiment Station.

DEAR SIR:

The accompanying paper on the "Forage Conditions of Central Montana" is the result of investigations made for the Station by Mr. Frank A. Spragg during 1900 and 1901, under the direction of the Botanical department of the Montana College of Agriculture and presented as his thesis on graduation from the Agricultural Course.

The field-work was done in Fergus county and the region immediately adjacent, during which nearly a thousand specimens were collected for the Station and many interesting facts regarding existing forage conditions in this region have been noted. These studies cover a portion of the state not readily accessible from the railway and hence little studied by botanists, although one of the most important sections from its stockgrowing interests.

Already the ranges in many parts of the state are showing signs of exhaustion and the number of stock supported upon a given acreage is steadily diminishing, while the recent tendency of the stockmen to purchase or lease these ranges for private use, tends to make questions as to their improvement and rendering them more productive of increasing importance. But before any systematic attempt can be made, it is necessary to determine the results of close-pasturage upon the ranges, the conditions formerly existing and those now found, as well as the various species of grasses, which form the component parts of these ranges, those found most hardy under pasturage and the most drouth resisting in dry seasons with their relative value for hay and pasturage. It is with these preliminary studies of the region in question that Mr. Spragg deals and his paper appears to be of sufficient importants to warrant its publication as a bulletin of this Station.

Mr. Spragg has also added a synopsis of all the genera of grasses found in the state by which beginners in this difficult order will be able

to work with more certainty in the determination of the different groups than with any of the schemes now available. It may be well to state that the collections upon which these notes are based have been compared by Mr. Spragg with specimens in our Station Herbarum, named by Dr. F. L. Scribner, while the more difficult species have been sent to the Division of Agrostology at Washington for determination.

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Bozeman, Montana, June 14, 1902.

FORAGE CONDITIONS OF CENTRAL MONTANA.

BY FRANK A. SPRAGG.

Geology and Physiography of the Region.

The portion of the country lying between the Missouri, Smith and Musselshell rivers is traversed by the Little Belt, Big Snowy, Judith, and Highwood mountains. It includes a great variety of conditions and fosters many industries, of which stock-raising is the principal, and large numbers of fat cattle and sheep are yearly shipped to eastern markets. Large quantities of wool are sold in the markets of Billings and Great Falls, or shipped east, and lately there has been a good demand for horses. The mountains are celebrated for mines of gold, silver and sapphires, and at their base are found limestone, gypsum and coal. Montana also has a belt of artesian water, due to the following conditions: running across the country, we have the outcrop of the coal seam of the Cascade geologic formation; this line of exposure crosses Sun river near the foot of the Rocky Mountains, and, swinging eastward, follows near the north edge of the Little Belt mountains, several miles south of Great Falls. At Sand Coulee and at Belt it presents vast workable seams of coal; continuing eastward, it follows Otter creek some fifteen miles, and crosses Arrow creek near its head; it then crosses Wolf creek four miles above Stanford, and the Judith river at Utica; running thence north of the Snowy mountains, it passes above Lewistown and around the west, north and east foot of the Judith mountains. Along this line of exposure are numerous coal mines furnishing the country with its total supply. This outcrop is

but the edge of one of many layers lapping against the mountains. Some of these layers are composed of clay and will not allow water to pass through; others are so loose and porous that large quantities of water disappear yearly along the foot of the mountains above the coal seam. A remarkable example of this is Dry Wolf creek, southwest of Stanford. Up in the mountains there is a swift stream about a rod in width in a bed of clay and gravel; at the mouth of the canyon this stream reaches the edge of a mass of loose, broken limestone; within two miles the entire stream has disappeared, and from there to its mouth, except in time of melting snow, the stream bed is but a mass of loose, dry gravel. Along the Snowies, and particularly around the Judith mountains, the larger portion of the water falling as rain and snow sinks in this way. Where does all this water go? Again, what are the Giant springs at Great Falls, and Big and Warm Springs in the east side of the Judith basin, if they do not have artesian sources? It is very noticeable, as one examines these springs, that the rocks around appear to have been shaken apart. One will notice a dark opening here and there with long strings of vegetation floating over, and a short distance down stream a big roll in the water may be noticed, showing that large quantities of water are flowing out.

Within a year previous to September 1, 1901, some half dozen artesian wells had been bored in the west side of the Judith basin and just below the outcrop of the coal. At Utica the water is spouting about eighteen inches above the opening of a three-inch pipe. Another company was boring a six-inch hole at Mr. B. E. Stack's ranch on Willow creek Sept. 4; they were then down 165 feet; they struck about ten barrels an hour at 257 feet, and bored to 317 feet. A good flow is expected at 500 feet, where they expect to finish the well, It is said that water was struck atUtica at 200 feet, though the well is now 800 feet deep, and on Sage creek at 80 feet, though the well is 393 feet deep. There is no reason why artesian water could not be found anywhere in the open country below the line of coal; there is but one difficulty presented. The amount of material piled on the top of the coal increases rapidly as one goes away from the mountains; on the Benton stage road atArrow creek, this mass is probably 1,500 feet thick, and at the mouth of the Judith at least

2,500 feet. The greatest depth the machine could bore, which was at Mr. B. E. Stack's Sept 4, was 800 feet.

The soil in the mountain parks is usually deep, mellow and rich, belonging to the Cambrian formation. Around the foot of the mountains, as has been seen, we have a belt of loose limestone. The soil is stony and useful mainly for pasture. Further out we have stretches of nearly level bench lands. Portions are covered with gravel, sand, and alluvium, and only clay enough to convert the whole into productive soils. This mass has been left in passing ages by streams as they drifted from place to place over this comparatively level country. The benches of the northern portion of this district are covered with clay, sand, polished pebbles, and some boulders. This glacial drift was left when the northern transcontinental ice sheet melted away. As a rule this drift contains less plant food than the bench gravels. Along the Missouri river, we find sharp gorges which have been cut in recent times through the bench gravels or glacial drift, exposing the clays of the Cretaceous below. These steep hillsides, sandy points, and stretches of worthless clays make up the badlands. These badband soils are low in plant food, rich in alkali, and next to worthless for cultivation. However, in the larger bottoms along the Missouri, crops of hay, grain and vegetables are often raised.

The Natural Plant Formations.

The grasses of Central Montana may be grouped, depending upon soil, moisture and situation, into six different, though intergrading, plant formations. These are: The Badlands, Alkali Flats, Prairie Benches, Wet Meadows, Foot-hills and Mountain Parks.

In the **Badlands** where the hills are rounded or flat-topped, we are apt to find the regular bench flora; but on the true side hill of this region, we find a scattering flora of salt-grass (DISTICHLIS SPICATA), June-grass (KŒLERIA CRISTATA), feather-grass (STIPA VIRIDULA), and here and there a bunch of blue-joint, (AGROPYRON OCCIDENTALE), on the better soil. On sandy points, putting down from the main hill, we find sand rush-grass (SPOROBOLUS CRYPTANDRUS), prairie rush-grass (SPOROBOLUS BREVIFOLIUS), and Indian millet (ERICOMA CUSPIDATA)

usually. In little bottoms and ridges between the main hill and the flats below, made up principally of sandy drift from the hillside, out of which most of the alkali has been washed, may be found a rich sod of blue grama (BOUTELOUA OLIGOSTACHYA). The two little pests, slender fescue (FESTUCA OCTOFLORA), and little barley (HORDEUM PUSILLUM), are often found here in clusters mixed with the blue grama.

The **Alkali Flats,** though often occurring in the Badlands, are commonly found in the open country. They are places where alkali water collects and evaporates. Portions of the great sag south of Benton are two hundred feet below the surrounding country. It contains six large lakes and several small ones; the larger ones are surrounded by bare alkali coated flats. White, dry patches are to be found in little sags quite generally over the country. As we recede from the barren patch, we first find salt-grass (DISTICHLIS SPICATA), and then by degrees June grass (KŒLERIA CRISTATA), and smooth bunch grass (POA LAEVIGATA). Depending upon conditions, we may also find rough-leaved salt-grass (SPOROBOLUS ASPERIFOLIUS), alkali meadow grass (PUCCINELLIA AIROIDES), and squirrel-tail grass (HORDEUM JUBATUM). In the non-alkaline soil on the edge of alkali places blue joint and blue grama are apt to be found, but these grasses can withstand but small quantities of alkali.

The **Prairie Benches** stretch from the Badlands and alkali flats to the foothills of the mountains. They are the drier upland portion of the country, crossed by creek bottoms and dotted by wet meadows, the grasses of which belong to a distinct flora, and are used principally for pasture. The principal grasses of the benches are blue grama (BOUTELOUA OLIGOSTACHYA), and blue joint (AGROPYRON OCCIDENTALE). Prairie June grass (KOELERIA CRISTATA), needle grass (STIPA COMATA), bunch wheat grass (AGROPYRON. DIVERGENS), and two or three meadow grasses (POAS) are also found more or less scattered. Around intermittent pond holes are found hair grasses (AGROSTIS HIEMALIS) and squirrel-tail grass, and floating foxtail mixed with two or three sedges in the bottom.

It has been mentioned that the meadow grasses grow very scattered on these benches to-day, and belong in large part to what was once

POA TENUIFOLIA. Prof. F. L. Scribner, who saw the country in the summer of 1883 says, "Poa tenuifolia may be regarded as the grass of the country. No species withstands the long summer drought so well, and it constitutes the chief forage upon the dry bench lands." As this grass is almost exterminated to-day, it is evident that it cannot endure over-stocking. A rancher who came to the country shortly after 1880, describes the grasses of these benches then as a thick mass of leaves shading the ground and growing to a hight of six to eight inches. He says further that this mass of leaves was inclined toward the southeast by the northwest winds. He did not know the name of the grass, but his description would lead me to call it blue-joint. To-day the blue grama (Bouteloua) is the most abundant as a mass of curly leaves covering the ground but two or three inches at the best. It is probable that in former times, before the ranges were over-stocked, that the meadow grasses (Poas), blue joint and other wheat grasses, and the prairie June grass, formed the greater part of the forage, and that the blue grama grew much ranker than it does now. In those favored times, some old timers say they could ride across the country with their feet dragging in the grass. The grass then fell to the ground each fall, and was in time transformed into a mulch, which thickened year by year and protected the ground from the hot sun. Large quantities of moisture thus retained enabled the grass to grow exceedingly rank. Perhaps none of the above named grasses have been exterminated for the lack of moisture, but on account of too close feeding, and the tramping of stock they have been so reduced in quantity as to be almost absent in some places. The blue grama, being the last of the grasses to succumb to the over-stocking process, has taken possession of the soil as the other grasses have disappeared. The difference, then, between the over-stocked range of today, and the luxuriant growths of former times is to be found simply in the relative abundance of the blue grama.

These prairie benches have proven themselves to be among the richest soils of the country. They are similar to those along the north base of the mountains, which will be considered under the head of foothills. The principal distinction is a slight difference in moisture Depending upon the amount of moisture present, the foliage of these

benches today, ranges from a thick mass of blue-joint leaves on down through all the gradations of the grama sod to where even this valuable grass has succumbed to a "moss" (Selaginella rupestris, Spring.) and desert conditions prevail.

The **Wet Meadows,** though characterized by atmost totally different flora, grades into the surrounding formations. The grasses present vary somewhat with conditions of soil and moisture. and depend largely upon the presence or absence of alkali. When water stands on the surface, we usually find rushes and sedges, or slough grass (BECKMANNIA ERUCAEFORMIS,), and reed meadow grass (PANICULARIA AMERICANA,), in small quantity. If the soil is wet, but not covered with water, prairie rush grass (SPOROBOLUS BREVIFOLIUS), alkali meadow grass (Puccinellia airoides), early bunch grass (Eatonia obtusata), tussock grass (Deschampsia cæspitosa), cord grass (Spartina cynosuroides), foul meadow grass (Panicularia nervata), and pale bunch grass grow in varying proportions. Or, in addition to the above if alkali is absent, reed canary grass (Phalaris arundinacea), along the banks of running streams. If alkali is present in small quantity and the soil is not very wet, rough-leaved salt-grass (Sporobolus asperifolius), and especially prairie rush grass (Sporobolus brevifolius), are apt to be found in large quantity. If the alkali is very strong all the above named grasses may be killed out and only salt-grass remain.

The region considered as **Foothills** here is not necessarily a strip extending out in all directions from the base of the mountains. We are considering the character of a certain group of grasses that may be regarded as belonging to the foothill flora. The prairie bench formation seems to extend to the foot of the mountains on the south side of the smaller mountain ranges of the plains, while on the north side of the same ranges are semi-circular areas, the flora of which does not resemble that of either the prairie-bench or the mountain-park formations. The soil, as has been said, is similar to that of the dry benches but receives more moisture. The strip north of the Little Belt mountains is wide to connect them with the Highwoods along the divide between the Arrow Creek and Belt Creek basins. These hills are today dotted by thrifty crops and meadows. A few years ago this foothill country was used only for pasture, as the dryer

benches are today. On the upland benches the sheep-fescue (Festuca ovina,) and red fescue (Festuca rubra) take the place of the blue grama of the prairie. In nooks partly sheltered by the mountains, snow-grass (Festuca campestris) is the principal forage. A large number of grasses are to be found here. The hays are mainly the cultivated and mountain timothy; Bromus inermis is only just coming into cultivation. There are several native grasses that no doubt would do well under cultivation, among which are the wheat and brome grasses, or for wet land the reed canary grass.

Grasses are also coming in on the mountain side where the timber has been burned off and the soil is not too stony. The principal of these are the western brome (Bromus Pumpellianus), pale bunch grass (Poa lucida) wood meadow grass (Poa nemoralis), downy oat-grass (Trisetum subspicatum) timothy (Phleum pratensis), and four wheat grasses (Agropyron).

About forty different varieties of grasses are found in the **Mountain Parks** of Central Montàna between the altitudes of 5000 and 7000 feet. The loose deep rich soil is literally fiilled with the roots of plants that probably bloom each and every month during the summer. The quantity of native forage is usually no greater than in the foothills and many of the grasses are similar. The hay grown here is mainly timothy or oat-hay. Under native conditions the land is often too rough to cut wild hay. It is said that clover and alfalfa will not do well. There are some of the native grasses that are certainly worthy of trial and some of these may be found superior to any of the tame varieties for cultivation at high altitudes and in mountain parks. Among them are mountain timothy (Phleum alpinum), mountain foxtail (Alopecurus occidentalis), mountain rye grass (Elymus glaucus), slender wheat grass (Agropyron tenerum), western brome grass (Bromus Pumpellianus), and snow-grass (Festuca campestris).

Economic Considerations.

There are still many problems to be considered that relate either directly or indirectly to the forage conditions of this region. Notably among these are the water supply, and its most economic use as well as

the improvement of the ranges. Large quantities of water go to waste one way and another. A few snowbanks remain in the mountains to supply water for irrigation, but most of the water runs off during the spring break-up to deluge the people along the lower Mississippi. Why should not a portion of this be saved in reservoirs for irrigation and to water stock later in the summer? The government has surveyed over thirty reservoir sites, mainly in Central Montana. It may be that the artesian supply will also become important. The amount of water needed to benefit a given meadow should be more carefully studied. Blue joint is universally regarded as the richest hay of the country, and by careful irrigation our native uplands will yield good stands; yet when water stands on the surface this grass disappears and is replaced by rushes, sedges and the less valuable grasses of the wet meadow flora It must be borne in mind that our most valuable grasses do not grow in swamps. Most of them are easily drowned out and replaced by others less valuable. "Under the present conditions one may frequently see a man injuring his meadows and fields by using too much water, while those of his neighbor some miles down the valley are suffering, perhaps totally ruined, for lack of the water."

When the pioneer came west he found the ranges covered with vast forage resources. The question then was, how can we get stock enough to use this wealth? Now conditions have changed. There is more stock on our ranges than they can support. Each rancher "knows that if his stock does not eat the grass, that of somebody else will, and naturally he thinks he might as well benefit by it as anyone. In his effort to get his 'share' he contributes to the general destruction instead of trying to avert it."

As conditions are drifting now, it is only a matter of time when all the public domain will be owned or leased by the ranchers. If the rent can be made reasonable so as not to exterminate the smaller owners, they will be given an incentive to adopt measures for the betterment of their holdings, and knowing that they and not someone else will get the benefit of their endeavors, they will make the subject a study and year by year their ranges will be enabled to support more and more stock. It has been asserted that all the ranges need is rest, but it has been pointed out, in speaking of the blue grama, that conditions have come where the most valuable of our range grasses have been nearly exterminated. The reseeding of the ranges is a problem that each rancher must study for himself.

Generic Key to the Grasses and Grass-like Plants of Montana.

Note.—In the following scheme the word "glume" signifies the outer empty scales; "pale" denotes the inner scale enclosing the flower; and "spike" is used to indicate any dense cylindrical inflorescence. Number before name indicates paragraph.

Perianth of six glumaceous segments; capsule 3-valved........................A.
Perianth of bristles, minute or none:
  Flowers in the axil of single glumes; stems solid; sheaths closed ...... B.
  Flowers enclosed in a pair of glumes; stems hollow; sheaths split...... C.

A. Juncaceæ (RUSH FAMILY).

Leaf-sheaths open; capsule 1-3 celled, many seeded; placenta parietal or axial.
  Plants never hairy; on moist ground........................... JUNCUS.
Leaf-sheaths closed; capsule 1-celled, 3-seeded; placenta basal. Plants usually
  hairy; often on dry ground............................... JUNCOIDES.

B. Cyperaceæ (SEDGE FAMILY).

1. Flowers perfect; spikelets all similar 2
1. Flowers monœcious or diœcious, usually borne in separate spikelets.. CAREX.
2. Spikes in single or umbelled terminal heads; spikelets 2-rowed.... CYPERUS.
2. Glumes spirally imbricate all around.................................. 3
3. Base of style swollen, persistent as a tubercle on the achene; spikes solitary............ .... ELEOCHARIS.
3. Base of style narrow, deciduous...................................... 4
4. Spikes one to many; bristles 1-6 included, rarely none............. SCIRPUS.
4. Spikes few; bristles 6-many, soft, very long, slender, and much exserted. ....ERIOPHORUM.

C. Gramineæ (GRASS FAMILY).

Inflorescence spicate.. 2
Inflorescence, a raceme of unilateral spikes; spikelets 2-rowed.............. 20
Inflorescence, a compound raceme of panicled spikelets.................... 21
Inflorescence, of paniculate unilateral spikes 19
Inflorescence, an open panicle 23
2. Spikes equilateral, cylindrical to capitate.................................. 3
2. Spikes unilateral.. 4
3. A strictly cylindrical spike; spikelets one-flowered, close, and equally distributed on axis 5
3. Spikes short, ovate to capitate 6
4. Unilateral spikes, paniculate, often loose................................. 19
4. Unilateral spikes racemose... 20

5. Glumes united at base, awnless; pale one, awned....... 12-13, ALOPECURUS.
5. Glumes distinct. mucronate; pales two, awnless..............58, 59, PHLEUM
6. Spikelets unisexular and dissimilar; staminate and pistillate on the same or separate plants..BULBILIS
6. Spikelets with one perfect flower and often another imperfect 7
6. Spikelets with two to many perfect flowers 12
7. Three spikelets at each joint of articulate rachis............48-50, HORDEUM.
7. Spikelets not all alike, usually in twos; axis of spikes or racemes hairy; fertile glumes awned.................................14, ANDROPOGON.
7. A large, short spike or a panicle of these; spikelets but one at a place, not clustered, awnless.......................................57, PHALARIS
7. Flowers perfect, single.. 8
8. Pale awned or sharp pointed.. 9
8. Pale awnless, shorter and broader than the glumes...................... 10
9. Pale awn terminal or absent; pales firmer than glumes and closely enveloping the grain... 11
9. Pale awn dorsal; grain loose or not at all enclosed.................... 10
10. Tuft of long silky hairs at base of pale............24-29, CALAMAGROSTIS.
10. Pale not hairy...9-11, AGROSTIS.
11. Pale sharp pointed to long slender awned............ 54, MUHLENBERGIA
11. Pale with long, stout, twisted awn........................... 72-75, STIPA.
12. More or less paniculate, spikelets not sessile......................... 13
12. Spikelets sessile on alternate notches of the rachis................... 15
13. Pale obtuse or with short terminal awn................................ 14
13. Pale awn dorsal, twisted and bent:
    (a) Spikelets 9-16 mm. long....................... 32-34, DANTHONIA.
    (b) Spikelets 4-7 mm. long............................. 76, TRISETUM.
14. Pale sharp pointed; spikelets in very short clusters mixed with leaves .... MUNROA.
14. Pale obtuse or acutish; first glume narrowly linear, second glume broadly obovate...37, EATONIA,
14. Pale and glume both acute and about the same length....... 52, KŒLERIA.
14. Pale usually awned at tip; flowers distinct................. 44-47, FESTUCA.
15. Spikelets solitary at each joint of the rachis 16
15. Spikelets two, rarely as high as six, at each joint of rachis.......... 18
16. Cultivated grasses (wheat and rye); pale sometimes keeled............... 17
16. Native grasses; pale round on back .... 1-8, AGROPYRON.
17. Nerves of pale convergent at tip; glumes 1-nerved................ SECALE.
17. Pale nerves parallel; glumes 3-many nerved. (Wheat) .... TRITICUM.
18. Rachis not articulate; glumes entire......................... 38-42, ELYMUS.
18. Rachis articulate; glumes two or more parted................ 67, SITANION.
19. Spikelets one to two flowered, subsessile on two sides of a subtriangular rachis in a long narrow panicle........................ 17, BECKMANNIA.
19. Spikelets many-flowered, much flattened, subsessile, and densely crowded in thick one-sided clustered .... DACTYLIS.

20. Spikelets crowded in two rows on one side of rachis. Prolongation of rachilla triaristate .... 18, BOUTELOUA.
20. Spikelets flattened, subsessile and strongly compressed on two sides of a triangular rachis .... 68, SPARTINA.
20. Spikelets obtuse, often short-pedicelled, and scattered; first glume usually shorter than the second .... PANICUM.
21. One perfect sessile flower alternating on two sides of a slender three-sided rachis .... 66, SCHEDONNARDUS.
21. Two to many perfect-flowered, pedicelled spikelets 22
22. Glumes one to two nerved; pales 3-nerved .... ERAGROSTIS.
22. Glumes 3-9 nerved; pales 5-many nerved .... 53, MELICA.
23. Spikelets with one perfect flower and often another imperfect 24
23. Spikelets with two to many perfect flowers 31
24. Spikelets usually in twos, not all alike; axis of spikes or raceme hairy; fertile glumes awned .... 14, ANDROPOGON.
24. Spikelets not more than one in a place:
    (a) Containing no abortive flowers 25
    (b) With abortive flowers; first glume shorter, awnless .... PANICUM.
25. Pale firmer than glume and closely enveloping the grain 26
25. Pale usually thin, not as firm as glume; grain loose or not at all enclosed . 28
26. Pale entire bearing a terminal three-branched awn .... 15, ARISTIDA.
26. Pale awn terminal or between two teeth, simple 27
27. Pale sharp pointed to long slender awned .... 54, MUHLENBERGIA.
27. Pale tipped with a long, stout, twisted awn .... 72-75, STIPA.
27. Floret globular, clothed with long, silky hairs .... 43, ERIOCOMA.
28. Rachilla usually bearing a tuft of long silky hairs produced beyond it; pale membranous .... 24-29, CALAMAGROSTIS.
28. Rachilla usually bearing a tuft of long silky hairs at base of pale. Tough sand-binding grasses .... 30, CALAMOVILFA.
28. Base of pale naked or thinly barbed 29
29. Pale sessile in glumes 30
29. Pale stalked in glumes, awned on back .... CINNA.
30. Pale acute, awnless; glumes two, shorter than pales; spikelets sometimes two-flowered .... 69-71, SPOROBOLUS.
30. Pale obtuse, often awned on back; glumes two, longer than pales .... 9-11, AGROSTIS.
30. Pale obtuse, keel often extending into a short awn; glumes four, longer than or as long as pales .... SAVASTANA.
31. Pale-awn dorsal or between two lobes at apex, more or less twisted and bent 32
31. Pale awnless or with a terminal straight awn; glumes shorter than pales.. 35
32. Pale-awn between two teeth or lobes, twisted and bent; spikelets 9-16 mm. long .... 32-34, DANTHONIA
2. Pale-awn dorsal or basal .... 33.

33. Spikelets less than 10 mm. long 34
33. Spikelets more than 10 mm. long .... 16, AVENA.
34. Pale obtuse; awn taper-pointed, not articulate .... 35, DESCHAMPSIA.
34. Pale 2-toothed; one or two of uppermost florets awned .... 76. TRISETUM.
35. Tall reed-like grasses; long hairs on rachilla .... PHRAGMITES
35. Not reed-like; pale naked or with hairs shorter than glumes 36
36. Pale 1-3 nerved 37
36. Pale 3-many nerved; spikelets 2-8 flowered, 5-20 mm. long; first glume 3-5 nerved, second 5-7 nerved .... 53, MELICA.
36. Pale 5-many nerved 39
37. Glumes nearly equal in length but very unlike, the first narrowly linear, the second broadly obovate, obtuse .... 37, EATONIA.
37. Glumes unequal in length but similar in shape 38
38. Spikelets 2 rarely 3-4 flowered; 2-4 mm. long .... CATABROSA.
38. Spikelets many flowered 2-18 mm. long .... ERAGROSTIS.
39. Spikelets 6-8 mm. long, densely crowded in thick one-sided clusters. (Cultivated) .... DACTYLIS.
39. Rays in whorls of 1-5 or more; glumes awnless 40
40. Lateral nerves of pale nearly parallel, not converging; glumes shorter than pales. Moist meadows usually 41
40. Lateral nerves of pale arched and converging above 42
41. Glumes nerveless or 3-5 nerved; pales with 3-9 conspicuous nerves; spikelets 2 mm. broad, and 3-15 mm. long .... 55-56, PANICULARIA.
41. Glumes 1-3 nerved; pale obscurely 5-nerved; spikelets 2 mm. wide and 3-7 mm. long .... 65, PUCCINELLIA.
42. Rachilla fringed with downy, cobweb-like hairs around the pale; pale usually obtuse awnless; spikelets 3-10 mm. long .... 60-64, POA.
42. Spikelets 5-13 mm. long and not crowded on the naked rachilla; pale round on back, sometimes keeled and often awned .... 44-47, FESTUCA.
42. Spikelets 10-40 mm. long; rachilla naked; pale often awned .. 19-21, BROMUS.

Annotated List of the Grasses of Central Montana.

1. Agropyron occidentale, Scribn, Blue Joint or Blue Stem. [Fig 1].

This grass, popularly known as blue-joint, grows on mixed soils of clay, sand and gravel and is found widely scattered from the edges of heavily alkaline soils through the upland prairie benches and foothills to the mountain parks. Growing alone, it often forms a thick rank mass of foliage on rich black loam meadows which are overflowed by water periodically. Under these conditions it forms the very richest and best hay of the country. Where water stands on the surface in summer, it kills out easily and in its place come rushes, sedges and the grasses of the wet medow flora. Where over-irrigated, alkali, too, is apt to come in, and grasses, like salt grass, which can better endure alkali, take the place of the blue joint. Its scattered growth seldom heads out on the prairie benches today. It is easily killed out by the close grazing and tramping of stock.

1. AGROPYRON OCCIDENTALE, Scribn. (U. S. Div. of Agros.)

2. Agropyron occidentale molle, Scribn. Colorado Blue-stem.

3. Agropyron divergens, Nees. Bunch Wheat Grass.

On the prairie benches this forms bunches often a foot in diameter and one to two feet high. Clustered near the edge of steep slopes, they are often, at a distance, mistaken for sheep by strangers. In the foothills it blends with other grasses to form valuable upland meadows. Growing alone, it often covers south exposures. When cut yearly, it makes good hay for horses and cattle, but is rather coarse for sheep.

4. *Agropyron Gmelinii*, S. & S. Short-leaved wheat grass.

5. *Agropyron pseudorepens*, S. & S. False quack grass.

These resemble blue-joint in many of its habits and are popularly confused with it, but are rather rare.

6. *Agropyron Richardsoni*, Schrad. Bearded wheat grass.

This grass grows in moist meadows, in the foothills and in mountain canyons and parks. It appears to intergrade with *Elymus glaucus*.

7. *Agropyron tenerum*, Vasey. Slender wheat grass.

In the prairie portion of the country, it is sometimes found in ravines and meadows, but often in thickets of rose and buck brush. It makes as good or better hay than timothy, and is sometimes found alone or mixed with a few other rank grasses in creek bends of the foothills.

2. Agrostis alba, L.
(U. S. Div. of Agros.)

8. *Agropyron violaceum*, Lange. Mountain wheat grass.

This grass is found high on mountain sides, in mountain parks, and in the upper edge of the foothills. It seldom grows alone, but adds its value to the general grass flora.

9. *Agrostis alba*, L. Red Top. [Fig 2].

This tame grass is to be found to-day in many parts of the country. A few years ago large quantities of the seed were shipped in and sold out to the ranchers of two or three localities. They were looking for a drought-resisting grass, and as this received high commendation by the store-keeper,

they sowed it on land where other grasses had failed to give a good crop. The resulting failure caused many people to condemn it; yet it has been found to make rank growth of hay on land that is too wet for most other grasses—land usually covered by rushes and sedges. However, the land must not be submerged. If those who have drowned out their blue-joint meadows would sow red-top before the rushes and sedges come in, they may still expect good hay. If the rushes and sedges have taken possession, it may be necessary to plow the land before the red-top will catch.

10. Agrostis asperifolia, Trin. Rough-leaved bent-grass.

This grass, though resembling red-top in many ways, grows on much dryer land and to greater altitudes, but will not furnish as large a quantity of hay. With other grasses, it sometimes forms a large portion of the vegetation in certain mountain meadows.

11. Agrostis hiemalis, B. S. P. Hair grass, or tickle grass.

Widely scattered from the alkaline flats of the Badlands almost to the mountain tops, this grass grows around the edge of intermittent pond holes mixed with what is popularly known as foxtail (HORDEUM JUBATUM). In some respects it resembles red-top and is often found mixed with it, but is almost worthless for hay.

12. Alopecurus geniculatus, L. Floating foxtail.

Mixed with two or three small sedges, this grass covers the bottom of intermittent pond holes and portions of river flood-plains, as the low bank of the Missouri above Great Falls. It sometimes grows to a height of a foot or more, but falls easily.

13. *Alopecurus occidentalis,* Scribn. Mountain Foxtail. [Fig 3.]

Though this grass was found by the writer only in the upper end of Belt Park under the shade of small clumps of white pine, it is reported at high altitudes throughout the Rocky Mountain region. In alpine meadows it often makes a remarkably luxuriant growth, frequently reaching a height of three or four feet. Its foilage is soft, but it is probably one of the most promising of the native grasses for cultivation in meadows at the higher altitudes and in moist partly shaded mountain parks.

14. *Andropogon scoparius,* Mx. Little Blue-Stem.

Grows in clumps a foot or two high on steep gravely side-hills and in the bottoms of rocky ravines of the drier portion of the country. It heads out late in August and is tough and woody, not usually eaten by stock.

15. *Aristida longiseta robusta,* Merrill. Dogtown grass.

Its habits are very similar to those of *Andropogon scoparius.*

3. Alopecurus occidentalis, Scribn.
(U. S. Div. of Agros.)

16. *Avena Americana*, Scribn. American oat-grass [Fig. 4].

This is found principally on the upland benches of the foothills and the dryer portions of the mountain parks, but it is also seen in mountain canyons and in sheltered ravines of the plains. It grows from a few inches to a foot high. Mixed with other grasses, it adds greatly to the value of the forage, but will never form a meadow by itself.

4. Avena Americana, Scribn.
(U. S. Div. of Agros.)

17. *Beckmannia erucæformis*, Host. Slough Grass. [FIG 5].

5. Beckmannia erucæformis. Host.
(U. S. Div. of Agros.)

The name slough grass is popularly confused with a collection of broad-leaved sedges, not grasses at all. This grass grows in shallow water with rushes and sedges.

18. Bouteloua oligostachya, Torr. Blue grama [Fig. 6].

This is today the most abundant grass of the dry plains region and is undoubtedly the richest. It grows on dry, porous non-alkaline soil usually, and is not found in buffalo wallows or wet places or on stiff clays. On the dry benches the foliage is a mass of curly leaves covering the ground but two or three inches high at best. In some places, where new soil is washed down from the hillside above by every heavy rain, the brown fruited stems of the blue grama are often ten inches high and thick enough to remind one of waves of water when the wind blows. "This grass improves very rapidly under cultivation. For several years it has grown luxuriantly in the experimental grounds of the Department at Washington. D. C., starting to green out about the middle of April and growing from 18 to 30 inches high, varying with the seasons."

6. Bouteloua oligostachya, Torr. (U. S. Div. of Agros.)

19. Bromus inermis, L. Smooth brome grass.

This extremely valuable imported grass is slowly but surely making its way into the confidence of the people. It is very hardy, and when once established it is green earliest in the spring and the latest in the fall. When not too dry it yields a stand of rich hay that all kinds of stock eat with relish.

20. Bromus marginatus, Nees. [Fig. 7].

This native brome grass is widely distributed from the edge of the badlands almost to the mountain tops. In the prairie portion it grows mainly in the heads of little draws patting down into ravines.

21. Bromus Porteri, Nash.

Has about the same distribution as the preceding, only in the prairie region it grows in clumps of small brush, like AGROPYRON TENERUM.

22. Bromus Pumpellianus, Scribn. Western brome grass.

This native brome grass resembles BROMUS INERMUS in many of its habits. Occurs on mountain sides principally and, where the timber has been killed by fire, it gives promise of forming good forage. It was cultivated at the Ottawa experiment station and considered a very valuable grass.

23. Bromus Richardsoni, Link.

Found in similar situations with B. PORTERI.

24. Calamagrostis Canadensis acuminata, Vasey.

7. Bromus marginatus, Nees.
(U. S. Div. of Agros.)

In the timber on mountain sides, its broad-leaved, tender foliage may nearly cover the ground and is probably mixed with two other members of this genus. In semi-moist, partly shaded portions of mountain parks, it often furnishes large quantities of summer forage.

25. Calamagrostis hyperborea Americana, Kearn.

Found only in mountain parks, it grows slightly more in the open than the last.

26. *Calamagrostis hyperborea stenodes*, Kearn.

27. *Calamagrostis montanensis*, Scribn.

Seldom found in the mountains; these grasses grow on stiff clays, on upland alkaline lands, or even on the dry open benches. They are commonly mixed with prairie June grass (KOELERIA CRISTATA) and popularly confused with it.

28, *Calamagrostis purpurascens*, R. Br.

Found in bunches on the tops of mountains, on mountain ridges and among broken rocks on rugged mountain sides.

29. *Calamagrostis Suksdorfii*, Scribn.

Found under about the same conditions and often with C. HYPERBOREA AMERICANA.

30. *Calamovilfa longifolia*, Hack. Big Sand Grass.

This tough, broad-leaved grass is valuable to bind loose drifting sands. Commonly found in circular patches in dry sandy swales and on sandy hillsides, where it grows almost to the exclusion of all other grasses. It often covers sandy bends of the Missouri river, and is used for pasture and sometimes even for hay.

31. *Cyperaceae*. Sedges, or slough-grass.

These broad-leaved plants resemble the true grasses. They grow mostly in moist ravines and wet meadows, but one (CAREX FILIFOLIA, Nutt.) is also found on the dryest benches with the blue grama (BOUTELOUA OLIGOSTACHYA). Several more grow on mountain sides and in mountain parks.

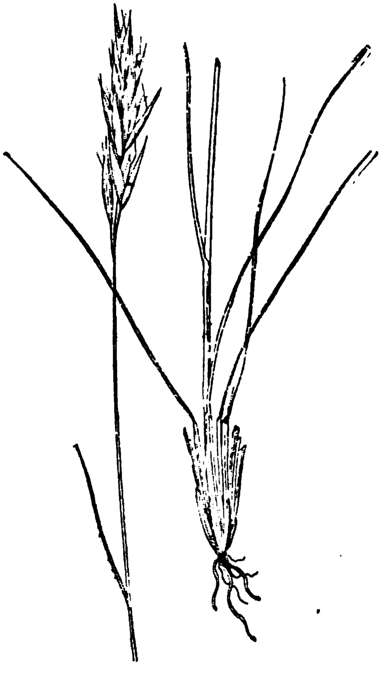
Meadows of rushes and sedges are valued highly by some on account of the fact that they furnish large quantities of hay yearly and will continue to do so indefinitely.

32. Danthonia Californica, Bol. California Oat Grass.

33. Danthonia intermedia, Vasey. Rocky Mountain Oat Grass. [FIG 8].

34. Danthonia unispicata, Munro. Tumble Grass.

These three grasses, though quite different, are also much alike, The first two are usually eighteen inches high and grow scattered. The last is four to eight inches high and found in mats on the edges of little sags. All grow in the foothills, and the first two also in mountain parks, at times well up on mountain sides. In the prairie region the first occurs only in narrow strips down the bottom of dry ravines.



8. Danthonia intermedia, Vasey. (U. S. Div. of Agros.)

35. Deschampsia caespitosa, Beauv. Tussock grass.

This grass requires about the same conditions as red-top (AGROSTIS ALBA), and is usually found in wet meadows and swamps where there is plenty of sun. "While neither the yield nor the quality of forage is equal to that obtained from timothy or red-top, there can be no doubt that this grass fills an important place among the native meadow and pasture grasses of this region." In places where many better grasses can not grow, it often converts bogs into useful meadow lands by means of its dense tufts and tough, fibrous roots. Continued mowing and pasturing have the effect of reducing its tufts to a fairly even sod, especially when a few other grasses act as fillers.

36. Distichlis spicata, Greene. Salt grass. Alkali grass.

Wherever this grass is found, one can say with fair certainty that there is considerable alkali in the soil. (See alkali flats.)

37. Eatonia obtusata, Gray. **Early Bunch Grass.** [Fig 9].

This grass is found in moist meadows, mainly those overflowed by water in the spring and nearly free from alkali. It makes excellent hay.

38. Elymus Canadensis, L. **Wild Rye. Canadian Rye-Grass.**

This grass is found in clumps of small brush and in moist shady nooks of the prairie. Mixed with other grasses in bends of creeks, it sometimes enters largely with the hay of lowlands. It is probably the most generally distributed and of the greatest value in meadows of all the rye grasses here.

9. Eatonia obtusata, Gray. (U. S. Div. of Agros.)

10. Elymus condensatus, Presl. (U. S. Div. of Agros.)

39. Elymus condensatus, Presl. Giant rye grass. [Fig. 10].

This coarse, tough grass is found in bunches a foot or two in diameter and from four to ten feet high. It grows in nooks of hills,

high bends of creeks, and at times on open bottom lands. When young, it makes hay of fair quality, but becomes tough and hard unless cut annually.

40. Elymus glaucus, Buckl. Mountain rye-grass.

This grass thrives in mountain canyons and parks and on mountain sides almost to the tops. It is seldom if ever found alone, but appears to increase in quantity in the parks as the altitude increases. It is certainly a valuable pasture and meadow grass for high altitudes.

41. Elymus Macounii, Vasey. Macoun's rye-grass.

42. Elymus triticoides, Buckl. Wild rye.

The above are two other rye grasses found in the foothills of Central Montana, but it is doubtful whether either of them is as important as the Canadian or Mountain rye-grasses.

43. Eriocoma cuspidata, Nutt. Indian millet.

In Central Montana this grass is mainly found in scattered bunches on sandy soil or hillsides in the edge of the badlands, but is also found more rarely on clayey soil and in the foothills. The foliage is tough and wiry.

44. Festuca campestris, Ryd. Snow grass.

In portions of the foothills partly sheltered by mountains and in sections of mountain parks, this grass grows nearly alone. In such places, it is found on mounds similar to the tussocks on which certain swamp grasses grow. From the top of these its long leaves lop over on all sides. It makes good pasturage, as it starts as soon as the snow is off in the spring, but it is extremely difficult to mow for hay. It is also found scattered in mountain parks, where it does not grow in mounds and forms only a small portion of the forage, but when mixed with other grasses may form valuable meadows.

45. Festuca octoflora, Walt. Slender fescue.

This strange little annual is found widely scattered over the plains portion of the country. Stock leave it, even when the blue grama is gnawed to the ground.

46. *Festuca ovina,* L. Sheep Fescue. [Fig 11].

47. *Festuca rubra,* L. Red Fescue.

On the upland benches of the foothills, on mountain ridges and in the drier portion of mountain parks, these two valuable grasses form the greater part of the forage and are together know as bunch grass. More or less scattered they are found on down to the edge of wet meadows. In their habit they resemble the blue grama, which is almost absent here.

11. Festuca ovina, L.
(U. S. Div. of Agros.)

12. Hordeum jubatum, L. (U. S. Div. of Agros.)

They grow in little circular bunches two or three inches over and include many varieties.

48. Hordeum cæspitosum, Scribn.

49. Hordeum jubatum, L. Squirrel Tail Grass. [FIG 12].

These two grasses, commonly known as "foxtail" through the country, are apt to be bad weeds on moist semi-alkaline soil. They are found around the edge of intermittent pond holes mixed with hair-grass (AGROSTIS HIEMALIS) and in strongly alkaline meadows mixed with salt-grass (DISTICHLIS SPICATA).

50. Hordeum pusillum, Nutt. Little barley.

This little pest grows similar to slender fescue (FESTUCA OCTOFLORA), crowding out the blue grama, and is not eaten by stock. It is mainly found in the edge of the badlands.

51. Juncacae. Rushes, or wire grass.

Small plants resembling the grasses growing in clumps along the bottom of dry ravines. and in moist meadows mixed with sedges, Their hay is low in food value, but is often cut in large quantity.

52. Kœleria cristata, Pers. Prairie June Grass. [FIG 13.]

This early grass rarely grows alone but adds greatly to the forage conditions. It is found on the top of the dryest hills and well down into the wet meadows. On alkaline land, if any grass except salt-grass will grow, it is apt to be found. Found throughout the badlands, prairie benches. foothills, mountain parks and is apt to be seen on the mountain sides as high as the grass will grow. It is the

13. Kœleria cristata, Pers. (U. S. Div. of Agros.)

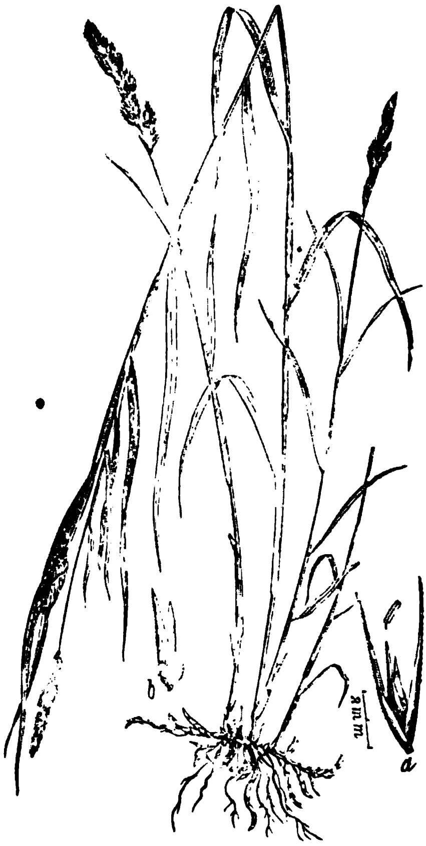
most widely distributed grass of the region. It matures early, dries up and furnishes a large quantity of seed. It is one of the first to afford pasturage in the spring and is much relished by stock.

53. *Melica cepacea*, Scribn. Slender-Flowered Melic-Grass.

Found in shady portions of Belt park only.

54. *Muhlenbergia racemosa*, *B. S. P.* Satin Grass. Wild Timothy. [Fig 14].

Found on gravelly soil around the edge of thickets, about a mile above Armington only.



14. Muhlenbergia racemosa, R. S. P.
(U. S. Div. of Agros.)

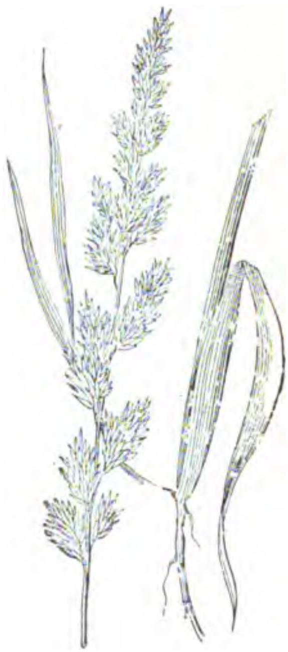
55. *Panicularia Americana*, MacM. Reed Meadow Grass. [FIG 15].

56. *Panicularia nervata*, Kuntze. Foul Meadow Grass.

57. *Phalaris arundinacea*, L. Reed canary grass. [Fig. 16].

These are usually found along stream margins and in low ground. The first two grow two feet, and the last four feet high. Under favorable conditions, they produce fair hay. The last is by far the most valuable. Some think it can be cultivated to advantage on land that now produces only rushes and sedges. It will not endure alkali.

15. Panicularia Americana, MacM.
(U. S. Div. of Agros.)



16. Phalaris arundinacea, L.
(U. S. Div. of Agros.)

58. *Phleum alpinum*, L. Mountain timothy. [Fig. 17].

59. *Phleum pratense.* L. Timothy.

The first is a native at high altitudes in mountain regions, while the last is one of the best known and most widely cultivated of the imported grasses. In mountain regions the latter has spread so rapidly of late years that it is difficult to say which is now in the greater abundance. In mountain meadows they form at times very large por-

17. Phleum alpinum, L.
(U. S. Div. of Agros.)

18. Poa lucida, Vasey.
(U. S. Div. of Agros.)

tions of the vegetation. The writer found patches where the common timothy had crowded out the native grasses so completely that it was difficult to believe that it had not been sowed on plowed ground.

60. Poa laevigata, Scribn. Smooth Bunch Grass.

61. Poa lucida, Vasey. Pale Bunch Grass. [FIG 18.]

These grasses are found widely scattered over the prairie benches, but do not fill anywhere near as important a place as formerly. In meadows overflowed by spring runs or irrigated moderately they make fine hay.

62. Poa nemoralis, L. Wood Meadow Grass.

63. Poa Nevadensis, Vasey. Nevada Blue-Grass.

64. Poa rupicola, Nash.

This was found in a few places on the prairie and on the tops of two mountains. It resembles the other meadow grasses in appearance and habits of growth.

65. Puccinellia airoides, W. & C. Alkali Meadow Grass. [FIG 19.]

This grass is principally found as one of the constituents of wet meadows. "It is not as well liked by stock as many other grasses. It possesses, however, alkali resistant qualities, which enables it to grow in soils which better grasses can not endure."

66. Schedonnardus paniculatus, Trel. Crab Grass.

This annual was found in old ruts in Sand Coulee, east of Great Falls.

67. Sitanion rigidum, J. G. S.

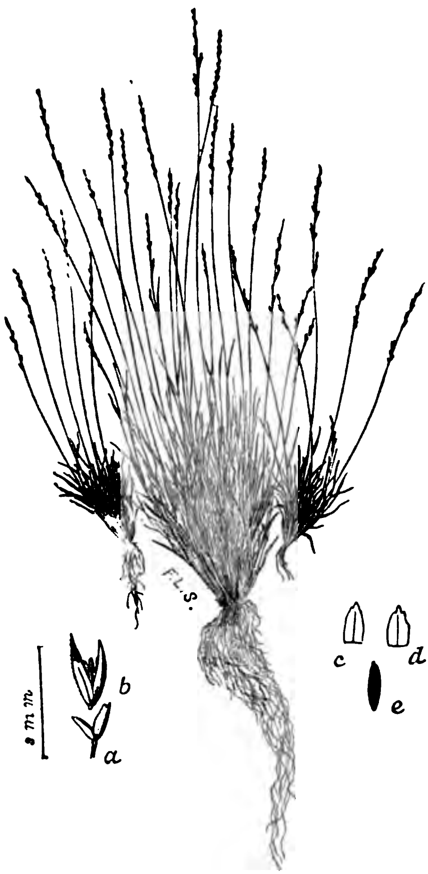
19. Puccinellia airoides. Watts. & Coult. (U. S. Div. of Agros.)

This stiff, long-bearded grass grows on rocky mountain tops, as at Square Butte, and among broken igneous rocks and limestone on rugged mountain sides. For stock, it is far worse than the squirrel-tail grass (HORDEUM JUBATUM).

68. Spartina cynosuroides, Willd. Big Cord Grass. [FIG 20].

This grass grows in or near shallow water, and adds to the forage of wet meadows. It is tough and generally avoided by stock.

20. Spartina cynosuroides, Willd.
(U. S. Div. Agros).



21. Sporobolus brevifolius, Scribn.
(U. S. Div. Agros).

69. Sporobolus asperifolius, Thurb. Rough-Leaved Salt-Grass.

Grows well on strongly alkaline soil and has little more value than salt-grass (DISTICHLIS SPICATA).

70. *Sporobolus brevifolius*, Scribn. Prairie Rush Grass. [FIG 21].

Scattered from the edge of the mountain region to well down into the badlands; thrives under all conditions except on the dry bench lands. It grows in patches thick on the ground and from four inches to two feet high, depending upon the amount of moisture. On the ranges, however, sheep leave it until the blue grama is gone. This grass gives promise of great value, as it withstands alkali well and in moist meadows furnishes a surprising amount of hay.

71. *Sporobolus cryptandrus*, Gray. Sand Rush Grass.

Grows in scattered bunches in sandy places, mainly in the badlands.

72. *Stipa comata*, F. & R. Needle Grass. [FIG 22].

This grass is widely scattered over the benches of the open country and its foilage is rich in food for stock. Its needles, however, are very sharp, and getting into wool, often penetrate the skin.

73. *Stipa Richardsonii*, Gray. Richardson's Feather Grass.

Found in the edge of the mountain region only. It appears to be inferior to STIPA VIRIDULA in value.

74. *Stipa spartea*, Trin. Porcupine Grass. Devil's Needles.

22. Stipa comata, Trin. & Rupr. (U. S. Div. Agros).

Resembles STIPA COMATA, but is taller and more erect, growing in the foothills mainly. Its needles are also sharper, longer and stiffer, and are more injurious to stock.

75. *Stipa viridula*, Vasey. Feather Bunch-Grass.

Usually grows in small bunches, but sometimes scattered, on stiff plastic clays of the badlands, and in nearly every semi-moist nook and corner of a hilly country, yet never in great quantity anywhere. In the foothills and mountain parks, it grows more in the open and often adds to the general value of the forage; does well under irrigation.

23. Trisetum subspicatum, Beauv. (U. S. Div. of Agros).

76. *Trisetum subspicatum*, Beauv. Downy Oat-Grass. [Fig 23].

Growing mainly on mountain sides and ridges and in mountain parks. This grass flourishes in a variety of soils, but is most commonly found in moist open woodlands or in the edge of thickets.

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BULLETIN NO. 37.

AGRICULTURAL

EXPERIMENT STATION

-- OF THE --

AGRICULTURAL COLLEGE OF MONTANA.

PORK PRODUCTION

IN MONTANA.

BOZEMAN, MONTANA, SEPTEMBER, 1902.

BOZEMAN CHRONICLE,
Bozeman, Montana,
1902.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

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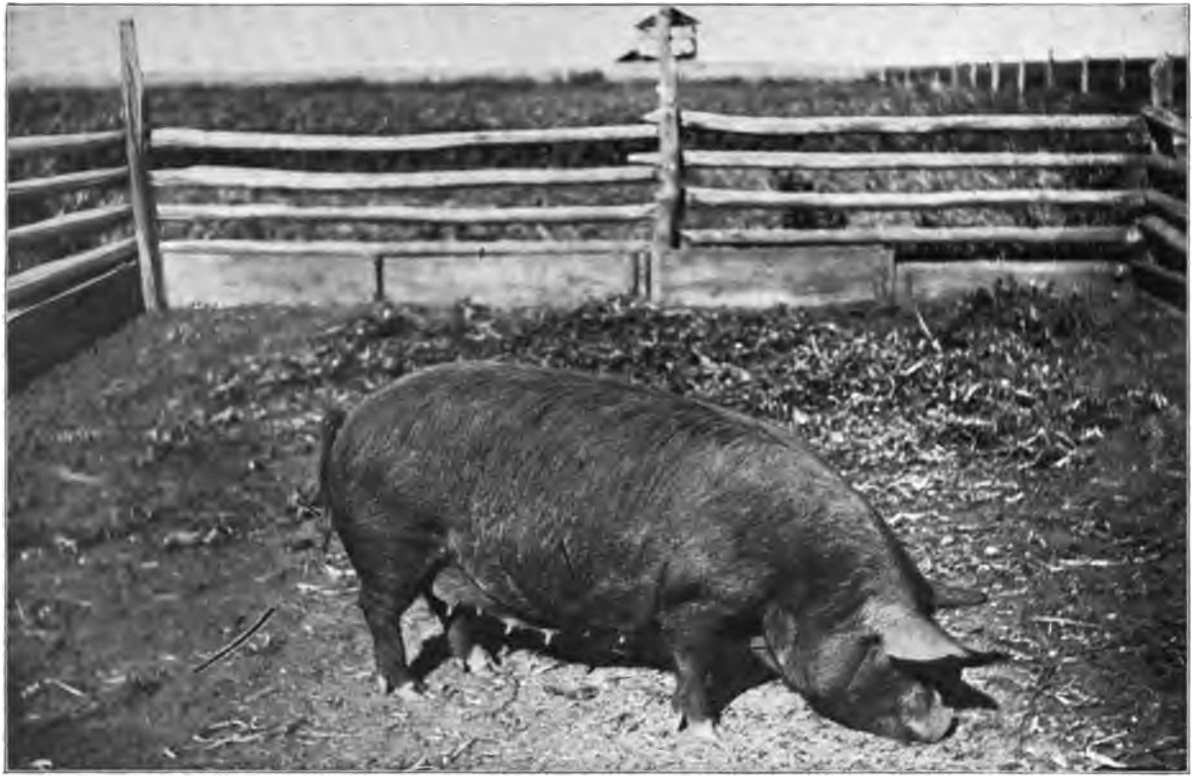

IMPROVED BERKSHIRE SOW. PROLIFIC TYPE. (LITTER 9 PIGS.)
PROPERTY OF THE MONTANA EXPERIMENT STATION.

POLAND CHINA SOW. LARD TYPE. UNPROLIFIC. (LITTER 3 PIGS.)
PROPERTY OF THE MONTANA EXPERIMENT STATION.

Montana Experiment Station.

Bulletin No. 37. - - September, 1902.

PORK PRODUCTION IN MONTANA.

BY R. S. SHAW.

The industry of pork production is in great need of encouragement throughout the arid west, which supplies but a small percentage of the pork required for home consumption. Western towns and cities are in large measure supplied with cured pork from the great packing houses of the east, with a product from the corn producing regions. There is a great demand for large quantities of cured pork in Montana. The occupations and conditions surrounding the people are such that large quantities of cured meat must be used of which pork is the chief. Ranchmen, stockmen, railroad and canal builders, miners, prospectors and campers living in places remote from the large centers can neither obtain nor handle fresh meats to good advantage. In many instances our farmers still continue to purchase cured bacon and ham, bearing packing house brands, from local merchants instead of producing them on the farm. Because of these practices our western farmers are failing to obtain a large revenue which they could so easily secure. Pork cannot be produced more cheaply or of better quality than in the irrigated regions of the arid west. Hog raising has been made possible by the opening up of agricultural lands which are made to produce enormous quantities of cereals and legumes by means of irrigation.

SUITABILITY OF CLIMATE.

The climate of the arid west is characterized by a light, dry air, prevailing sunshine and moderate temperature. No better combination of conditions exists for the healthy and rapid development of the pig. The cultivated regions are in general found between the altitudes of 2000 and 5500 feet, where little or no damp, cloudy weather occurs. These atmospheric conditions combined with an almost continued sunshine throughout the winter season

lessens, in fact almost entirely prevents, the occurrence of the many pig troubles so disastrous in the more humid regions. Throughout these regions extremes of temperature are not prevalent during long periods of time, and being short lived are easily endured because of the lack of humidity. In general the climatic conditions are such that the pig can run out of doors throughout almost the entire year, the snow fall being very light. These conditions tend toward vigor and healthfulness and permit of economic methods of feeding. Everywhere it is possible to provide abundant supplies of clear sparkling water from the mountain streams. A number of instances have been noticed in which breeding hogs imported from the corn belt have brought hog cholera among our western bred stocks. In one case 60 per cent. of the imported hogs died while only one mature hog out of twenty Montana grown ones succumbed, although all were effected. In this we have strong evidences of the constitutional vigor produced by the climatic and food conditions.

SUITABILITY OF FOOD PRODUCTS.

The pork producing foods grown in the arable regions of Montana consists of cereals, legumes and root crops, the marvelous productiveness of which has been heretofore described. The cereal grains include brewing and white and black hulless barley, spring club wheat, rye and oats. One legume, viz. peas, can be universally grown in great profusion. Forage crops, alfalfa, red, alsike and white clovers, peas, winter and spring rye and various grain mixtures produce an abundant variety of pasture throughout fully eight months of the year. Of the root crops best suited, sugar beets, mangolds and carrots can all be raised. While the great variety enumerated cannot all be grown in each cultivated section, still, there is no farm territory in Montana where a suitable combination of these cannot be grown. It is true that winter rye can be universally grown, and no section need be without some one or more of the legumes, cereals and root crops. It therefore follows that excellently balanced rations can be secured generally which will produce a good quality of pork, rapidly, cheaply and economically. It may appear to those from the corn belt that the inability to grow corn in most parts of Montana is a strong argument against the business. In peas, however, we have an excellent substitute for corn. Bulletins 34 of the Utah Station by Mills, and 38

of the South Dakota Station by Chilcott, both report peas superior to corn for fattening swine. Barley is reported by the famous Danish pork producers to be the best single grain for the production of high grade bacon. Director Henry of the Wisconsin Station gives the following comparison between corn and barley as pork producers, viz.:

471 pounds of barley meal produced 100 pounds of gain.

435 pounds of corn meal produced 100 pounds of gain.

Wheat—The results of several stations show wheat and corn to be nearly equal in pork producing value with a very slight advantage in favor of corn.

Oats—According to Henry's "Feeds and Feeding," the Massachusetts Station reports that 20 per cent. more oat feed than corn meal was required to produce 100 pounds of gain. Oats are more valuable as an adjunct to lighten heavier rations than when used alone.

Rye—The results of comparative work shows rye and barley to have about equal feeding values. These facts tend to prove that our grain foods are exceptionally well adapted to pork making, and at the same time the use of these is greatly facilitated by the possibility of a continuous supply of nitrogenous forage crops during a long growing season, and by root crops in the winter.

PREPARING FEEDING FOODS.

The most satisfactory results have been secured from grinding the grain feeds and soaking a short time before feeding. Under the arid conditions the cereal grains become so hard and flinty that they cannot be fed whole with good results. Local facilities are now such that grains can be ground at little expense. Where it becomes a necessity to feed whole grain this can be accomplished by scattering it on hard dry ground or a feeding floor, it will then be picked up little by little and is more likely to be masticated, whereas, if fed in troughs large quantities are swallowed, passing the digestive tract whole. Prices of labor are so high as to render the cooking of either grains or roots too expensive. Root crops can be fed to good advantage raw except where turnips or rutabagas are used.

FORAGE CROPS.

The climatic conditions and capabilities of crop production are such that pigs, old, young, breeders and fatteners, can forage dur-

ing fully two-thirds of the year. The secret of economy in pork production in Montana, consists in keeping the pigs foraging. Even though some expert investigations reveal the fact that a pig enclosed in a pen will make a greater gain from a given number of pounds of food than the pig running at large, still, it will pay better because of the cost of labor to let the pig go to the food than to bring the food to the pig. A succession of forage crops must be provided for, which means that from three to four lots should be fenced off near the hog houses. If alfalfa alone is relied on this should be divided into two parts to permit of recuperation and irrigation. Forage crops may be relied on for use in the following order, winter rye in April, alfalfa in May, the clovers in June, grain mixtures in July, and peas from August to the setting in of winter. These are the periods at which each of the crops named come into use. Of these crops alfalfa is one of the most important because of its permanency; where it cannot be grown some one ofthe clovers is sure to answer. Alsike clover is well adapted to moist situations and withstands very severe grazing. White clover will grow in a still wetter soil. Through the use of a liberal amount of water not more than four or five acres of forage is necessary to provide green food for a herd of from 40 to 50 pigs of all ages, from the opening up of spring till the pea crop and grain stubbles become accessible. Young growing pigs should not be required to forage for a living; a one-third grain ration should be supplied in order to secure a proper growth and development. Foraging alone will only provide maintenance and a small gain in live weight. The light grain ration advocated will materially assist in producing renumerative gains and prepare the young pig for fattening on the stubbles or peas in the autumn.

METHODS OF FEEDING.

THE BROOD SOW.

The brood sow can forage the greater part of the year. During the later stages of pregnancy a little grain food should be supplied, the amount depending upon her condition of flesh; this, however, will not be necessary during the time she is gleaning from the grain fields. The forage in general being leguminous any one of the cereal grains may be used as supplementary food. While nursing the litter access should always be given to the forage grounds when possible, and a liberal grain ration fed. Immediately after farrow-

ing a light ration of sloppy feed consisting of skim milk, shorts, bran and oats is most satisfactory: the heavier grain foods can be gradually added. During the period of rest or early pregnancy in the winter months the brood sow can be maintained on sugar beets, carrots or mangolds with a one-third grain ration added. Spring farrowing has hitherto been favored, but the climatic and food conditions are such that fall litters can be handled almost equally well.

YOUNG AND STORE PIGS.

These should have constant access to forage grounds in the summer season, and sheltered yards in the winter. When four weeks old they will take a little sweet skim milk to which some shorts or middlings may be gradually added, and later some ground wheat. A light grain ration should be supplied the young growing pig in addition to the forage throughout the forage season but may be entirely cut off as soon as the pigs reach the pea or grain stubble fields. During the winter season the shotes should have access to stacked alfalfa, clover, or peas, from which they will secure a large amount of food. Sugar beets should also be supplied.

THE FATTENING HOGS.

This process is most economically accomplished by finishing in the pea lots or grain stubble. The pigs should be turned on the peas as soon as the pods are filled and the peas begin to harden. If sufficient pigs are used, say 10 per acre, not a pea will be wasted and even a portion of the vines consumed. One acre of peas, producing at the rate of 35 bushels per acre, which is an average for Montana, will provide a fattening ration for ten 150 to 200 pound hogs for from 40 to 45 days. Climatic conditions permit of pea harvesting by pigs even as late as December 1. This is one of the easiest fattening methods now practiced in Montana. The area over which peas can be grown is very large and the time of foraging so extended by favorable weather that the product need not all be marketed at one time. In order, however, to make the best use of forage conditions, winter litters must be raised. Pigs from spring litters do not reach a large consuming capacity soon enough to take advantage of the early forage. Both late fall and early spring litters should be raised in order to get the most out of the foods and the market conditions.

RESULTS FROM GLEANING GRAIN FIELDS.

Enormous quantities of pork could be made annually from the grains wasted on stubble fields, large quantities of which are lost by "shattering" under the arid conditions.

During a period of 42 days extending from Oct. 4 to Nov. 15, 1901, the following test was made with pigs gleaning from grain stubble from which crops of oats, wheat, barley and peas had been removed. At the beginning of the test the 24 pigs weighed 2731, and at the close 3608 pounds. Thus in 42 days 24 pigs made an increase in live weight of 874 pounds, which amount valued at 5¼ cents, the prevailing price at the time, gave a return of $46.04. From this amount $3.28 is deducted for feed during a few days when the ground was covered with snow, there was then left a clear profit of $42.76. The percentage increase in live weight was 32.1 per cent. as compared with 19.2 per cent. from lambs and 5.19 per cent. from steers under the same conditions. One hundred and twelve acres of the station farm, consisting of meadow 57 acres, and the balance of stubble, formed the run for the 24 pigs, 230 lambs and 11 steers. There are enormous areas in Montana which could be put to a similiar use.

RESULTS SECURED FROM FEEDING GRAIN VS. GRAIN AND SUGAR BEETS.

In the spring of 1902, two lots of four pigs each were fed for 50 days, one on exclusive grain ration, the other receiving both grain and sugar beets, with the following results. The four hogs receiving grain made an increase of 316 pounds or 79 pounds each, making an average daily gain of 1.58 pounds. The cost of production per pound increase with this lot was 4.6 cents. The four hogs receiving grain and sugar beets made an increase of 328 pounds or 82 pounds each, making an average daily gain of 1.64 pounds. The cost of production in this case was 3.8 cents per pound. The former lot received a heavy grain ration of 9.11 pounds each per day. The latter consumed 6.65 pounds of grain and 4.58 pounds of sugar beets per head per day. The financial outcome of this test resulted in a net profit of $14.12 or 33 per cent. on the investment in 50 days. Previous tests conducted in 1900 gave the following results:

Cost of pork per pound increase from grain only	$3.33
Cost of pork per pound increase from grain and sugar beets	2.85
Food required per pound increase from grain only	5.32 lbs.
Grain required per pound increase from grain and sugar beets,	4.26 lbs.
Net profit per head from feeding grain only	$1.80
Net profit per head from feeding grain and sugar beets	2.28

One acre can be made to produce from 15 to 20 tons of sugar beets at a cost not exceeding $30 per acre. If for any reason these

cannot be grown carrots or mangolds can be made to take their place. Some insect pests which prey upon the young sugar beets and mangold plants will not harm the carrots. These roots can be fed whole and raw, at least expense, with satisfactory results. The sugar beet is the best keeper of the three.

THE KIND OF HOGS TO BREED.

Our conditions are well able to support large framed hogs which will mature moderately early. Strength of bone is desirable but not so necessary as in some other regions. The brood sow should be long bodied and rangy with good length and depth of coupling; such a one is more sure to be prolific, a good mother, and a good nurse, than the chunky, compact, fine boned, strictly lard type. These desirable features are found par excellence in the improved English Berkshire and good results can be secured from the large, rangy, strong types of Poland Chinas. Many of our breeders are making serious mistakes by breeding immature animals and also by inbreeding. Let the young sow reach ten or twelve months of age before producing her first litter, and then do not destroy her as long as she continues to produce good ones. Inbreeding has arisen because of the difficulty and cost of importing boars; injudiciously practiced, rapid deterioration of form, constitutional vigor and feeding qualities is sure to ensue.

HOG HOUSES.

Various improvised and inexpensive shelters are being used, from the dugout in the hillside to the pole shelter covered with straw and the building made of logs. While any of these may provide shelter during the milder portion of the year, their use can in no wise prove satisfactory throughout. They are too apt to be dark, damp, filthy and draughty. The pole structure with a straw covering may be used as a temporary shelter or for sleeping quarters for feeding hogs during the milder season, but for breeding quarters their use cannot be recommended. The log building is in most common use. Its greatest fault is its inability to retain the chinking. As a result the structure soon becomes open and draughty.

A properly planned and well constructed frame building gives the best results; its use is almost absolutely necessary where winter breeding is practiced. The building site should be high and dry so that surface water will drain away at all times. If possible the location should be in close proximity to the small fields which are

to produce the forage crop. If a natural water supply can be diverted so as to pass through the yards so much the better.

It is desirable that the hog house should face the south, and that each pen should open into a small enclosure fenced off, preferably with wire netting. By this means when a number of sows are confined with young pigs during the winter season they can have access to protected, sunny yards.

The size of the building will be determined by the number of brood sows and boars to be kept. As regards shape a long narrow building is preferable, of such proportions, for instance, as 16 x 48. In such a structure a 3½ foot passage way should run from end to end along the north side of the building, thus leaving all the pens on the south side. Pens 8 x 12½ will furnish room for a brood sow and litter or several fattening pigs, according to size. One pen of twice the capacity should be constructed to furnish sleeping quarters for a larger number of animals, although an extra shed could be constructed cheaply to protect the animals during the pasture season. Each pen should be provided with a small hinged door on the south, and directly above it a window. Not more than two windows will be required on the north side. The troughs should be placed directly under the partition adjoining the passage way, and this partition so constructed as to swing from the top. In this way the pigs can be excluded from the trough while the feed is being supplied. The swinging partition is held in place by means of a slide in the center which works up and down thus resting on either side of the trough as desired. Less food is wasted when the flat bottomed troughs are used. Because of its splintery nature hemlock makes a durable trough, the pigs not caring to chew it.

Concrete overlaid with cement furnishes a good flooring, its only fault being that it is cold. This may be overcome by overlaying a small portion with plank for a bedding place. Plank floors give good satisfaction but should be made water tight, or else much filth will work through and produce unsanitary conditions.

One or two ventilators should extend from within a few feet of the floor up through the roof; in many cases these do not extend below the ceiling and as a result remove only the upper warm air, leaving the foul, heavier air below. If necessary to secure warmth the inside may be lined and the spaces between the studs filled with sawdust or chaff. The chief essentials of a good hog house are warmth, sunlight, dryness and good ventilation without cold draughts.

BULLETIN NO. 38.

MONTANA AGRICULTURAL

Experiment Station

OF THE

AGRICULTURAL COLLEGE OF MONTANA.

FOOD ADULTERATION.

BOZEMAN, MONTANA, OCTOBER 1, 1902.

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Montana Experiment Station.

Bulletin No. 38 - - - - October, 1902

FOOD ADULTERATION.

F. W. TRAPHAGEN.

As a class the Montana Farmers should be more deeply interested in the subject of the adulteration of food and in the remedies for existing conditions, than any other group of citizens of our commonwealth. The reasons for the existence of this interest are twofold, namely, because as producers they suffer greatly by having their food products come into competition with the cheaper spurious products which so completely flood the markets today, and because as consumers they are constantly buying foods which are not true to name, but are either partly or entirely made up by the substitution of cheaper materials.

Fortunately the stress of the competition of low grade imitations with our own farm crops has not yet been felt to any great extent. That our farmers have this competition to meet in the future unless remedies are enacted for their relief, is shown by the fact that already, on a very small scale, the manufacture of preserves and jellies has been undertaken near Missoula, and the sale of these high grade goods has been seriously affected by the presence of so much of the cheaper "compounds" which are so plentiful in all our markets.

Nature of Food Adulteration.

For our purpose it will be sufficient to divide the adulteration of foods into two groups, first those which affect the pocket-book, and second those which affect the health.

In the first group we would place all cases of the substitution, in whole or in part, of cheaper, though wholesome, articles for the one which is presumably bought. Examples are the use of glucose for maple syrup, or for New Orleans molasses, or its substitution for the more expensive and sweeter sugar which is used in the higher grade jams, preserves and jellies. Corn meal is frequently used to adulterate wheat flour; cotton seed oil, peanut oil and sesame oil often masquerade as olive oil, ground spices are composed largely of ground cocoanut shells, and similar substitutions are made for other food materials.

Under the head of unwholesome adulterations would be placed substances which cause derangements of the digestive or other func-

tions of the human economy. Examples of these are the ground rock which was sold by the York Manufacturing Co., of Greenville, N. C., in carload lots for the adulteration of wheat flour. It is at once apparent that this material can have no nutritive value and that it further must tax the digestive organs greatly to effect its elimination.

We have been called a "nation of dyspeptics," that this name is justly applied is due to the fact that the use of food preservatives, which is prohibited in several foreign countries, is not restricted in this country except in the few states having effective food laws.

The case against these food preservatives is not as complete as it might be, but in the event of a reasonable doubt it is best to be on the safe side. The food preservatives in use at the present day are powerful antiseptics and for that reason have a decided restraining effect upon digestion. The question of the physiological effect of the extremely small quantities of any of these preservatives that would be taken with food when the minimum amount necessary for its preservation is used, is very important. It is probable that in such cases the vast majority of consumers would not be harmed. On the other hand, in the case of children or invalids much harm might result even with the smallest amounts of antiseptics. Where the use of such drugs as these preservatives is contra-indicated, it should be at least possible to avoid their presence in the foods consumed.

The arguments against the use of chemical preservatives apply with almost equal force to the artificial colors which are used so largely to improve the appearance of inferior goods. The testimony of experts on physiological chemistry given before the Committee on Manufactures of the United States Senate in its investigation of this matter, shows the prevailing opinion of those best qualified to testify on this subject.

A portion of this testimony is given in the Seventh Annual Report of the Montana Bureau of Agriculture, Labor and Industry, pages 499—507, and our readers are referred to this report.

The Remedy

After a futile attempt to secure the passage of a measure by our legislature for the protection of the citizens of our commonwealth we have reached the conclusion that the best way to secure relief is through the enactment of a measure by Congress.

The reason for this change of base on our part is primarily because such a measure, as was considered by our legislature, can only become effective by holding our own dealers responsible for the character of the foods they offer for sale. In the nature of things we cannot successfully legislate against producers or jobbers who reside in another state than our own. At the same time there is little doubt but that our dealers could protect themselves by exacting guarantees from their supply houses. That the wholesalers are willing to give such guarantees we have been assured by the

representatives of many of the firms doing business with Montana retailers.

Yet, the plea that the innocent (?) Montana merchant would bear the burden of prosecution, or persecution, as some of the grocerymen lobbyists chose to put it, proved a very effective argument with the members of the last Montana House. The difficulties of the administration of such a law as was proposed would have been great and there is no doubt that the work can be much better done by the Bureau of Chemistry of the Department of Agriculture at Washington than by the individual states. Of course a national law can only deal with interstate commerce in such goods, and with violations in the District of Columbia and in the Territories, hence the states will have to take care of all such violations of food laws as occur within their own limits. This phase of the problem need not trouble us for many years, for so far as we know, our own food products thus far have been above suspicion, and we believe will remain so for many years. A national pure food measure which we believe to be necessary to supplement the laws already in force in some states, and to afford protection to citizens of states having no laws on this subject, would be a boon to the farmer when he is considered either as a producer or as a consumer. The bills before the last session of Congress known as the Hansbrough Bill in the Senate, and the Hepburn in the House of Representatives, seem to be perfectly fair in every respect, and had the endorsement of numerous organizations which have no private "axes to grind."

The text of the Brosius Bill may be found on pages 489—492, Seventh Annual Report Montana Bureau of Agriculture. This bill is practically identical with the other bills mentioned.

Considered briefly in their essential details they place the administration of the law in the hands of the Secretary of Agriculture, with the details of administration given to the Bureau of Chemistry, which for years under the lead of the Chief Chemist, has been making exhaustive researches along all the lines involved in the successful enforcement of an anti-adulteration law.

There is no doubt that there is no laboratory nor corps of chemists so well fitted for such work as that to be found in the Department of Agriculture.

The bills make no prohibitions, but simply demand that articles be sold on their merits for what they are, and that they do not masquerade as something better.

The correct locality of production must appear, so that a state producing a particularly high grade of flour or superfine butter, may not be robbed of its honors by the false branding of other flour or butter, perhaps pure enough, but still decidedly inferior, and produced in some state which has yet to make a record in these lines. These matters are of immediate concern to farmers.

The opponents of these bills offer arguments, or rather an argument, which should disgrace any men. They protest that to compel them to lable glucose syrup correctly, and prevent them calling it maple syrup, is an infringement of personal liberty and an interference with their Constitutional rights. How a man can expose himself to the supreme contempt of his fellow men by such an argument, is beyond our comprehension. Yet this is precisely what many did in the public hearing of the supporters and opponents of these bills, when they were before the respective committees having them in charge.

For the protection of our agricultural and horticultural interests, it would be well if the numerous organizations, representing these industries, would become familiar with these measures now before Congress, and would use their influence to secure the passage of some suitable bill, such as the ones before mentioned.

The Conditions in Montana.

It will not be surprising to learn that, because of the absence of protective measures of any kind, adulterated food is common in Montana.

The adulterations are of both kinds, the deleterious and the fraudulent. Jams, jellies, preserves and catsups are found very generally colored with coal tar dyes, and when this is done it is almost always an evidence that it is simply done to hide another adulterant, starch paste, glucose or other cheap substitutes for the real food. When a preservative such as salicylic acid is used, its presence may be assumed to indicate the presence of glucose, or some other more readily fermentable substitute in place of a usual constituent.

As a matter of fact, the two substances just mentioned were very commonly found, and in addition, starch paste and glucose were their frequent companions. In the case of catsups the preservative is used mainly, not because of any substitution, but because the catsup is particularly subject to fermentation on account of the manner of using this condiment.

Vinegar was usually found sufficiently sour to pass muster in any place but its origin was frequently doubtful, and rarely was it made from apple juice.

To show how effective a national law may prove, it is only necessary to mention our experience in seeking oleomargarine in the Montana markets. While it is known that it is bought in the original packages for sheep camps, and possibly for grading crews, and in a few other cases, we suspected it might be on sale on the open market as butter. We were assured by the collector of internal revenue that none was retailed in Montana, but we wished to determine for ourselves how true this statement was. With this end in view we hired a small boy to buy for us in many stores the cheapest butter offered for sale. To our great surprise, while of course the samples were not the highest grade of butter, yet not one of the whole

lot was anything but butter. There was no evidence of the presence of lard or oleomargarine in any one of the samples.

Jams, Jellies and Preserves.

Probably no class of food materials is more generally adulterated than the jams, jellies and preserves. It is possible to get samples purporting to be one of these preserved fruit products which contains no fruit whatever. We have found samples in this state which contained glucose, starch paste, salicylic acid, a coal tar dye and some seeds which are likely the seeds of grass rather than of fruit. This comprised the contents of one of the jars of jam which we examined. In another series of jams there was a small amount of fruit in such condition as would allow of its easy recognition, but the great mass of the jam was made up of glucose syrup and starch paste, with a considerable amount of salicylic acid added to prevent fermentation.

See table of analysis on following pages.

Canned Soups.

In general, very little adulteration was found to be present in the canned soups examined. However, this is true of all the samples, that a dilution to the extent indicated on the label made an extremely "thin" soup, and at best the food values so obtained were extremely expensive. As a convenient and easily prepared food, these soups furnish an article that is all that could be desired, but as a part of an economical dietary they have no place.

See table of analysis on following pages.

Tomato Catsups.

It is doubtful if any article of diet so generally contains preservatives as do tomato catsups. The addition of preservatives to this class of foods becomes necessary because the article is not entirely used up as soon as opened, but may be placed upon the table day after day, and a little used at a time. The preservatives used most commonly are salicylic acid and benzoic acid, but others are occasionally used.

See table of analysis on following pages.

Cream of Tartar.

To make use of a form of expression commonly known as the Irish bull, many of the cream of tartars on sale in our state are something else; that is they contain no cream of tartar whatever. This is a condition that would be remedied by the operation of such a law as is comprised in the Brosius bill.

In many instances our merchants know what they are purchasing, and yet they sell these inferior goods under false names, and for better materials; the price however, is not lower. These so-called cream of tartars are what are known in the trade as "C. T. S." That is, cream of tartar substitute, an article made up of burnt alum, or acid calcium phosphate, or some other cheap acid constituent to take the place of the higher priced cream of tartar. Usually starch,

gypsum or some other worthless filler is added in addition.

One of the retailers told me he knew the sample I had just secured of him was not cream of tartar, yet he did not hestitate to sell it under a false name. In many respects some of our retailers are not more honest than the wholesaler who supplies their goods.

Baking Powder.

Four years ago when these investigations were undertaken for the first time, a very considerable number of low-grade baking powders were on the market. This year we have found a decided improvement, for not only have many of the lower grades disappeared from the state, but in addition there has been a decided improvement in the better grades.

The value of baking powder is primarily determined by the amount of gas eliminated by it under the conditions associated with the kneading and baking of bread. There is another condition, however, which is very important, and that is as to how the residues from the baking powders exist in the bread, and what the effect of such compounds is upon the human system. In making bread with yeast the principal products of the action of the yeast plant are the gas and the alcohol, the latter of which is entirely dissipated during the baking.

Cream of tartar baking powders leave in the bread the double tartrate of sodium and potassium, which is commonly known as Rochelle salt, so frequently used as a laxative. The phosphate powders are changed during the bread-making process into phosphates of calcium and sodium, neither of which may be considered harmful, and which may even have an important function in bone and tissue formation.

Of another type of baking powders, and of still another to a less degree, one cannot be quite so confident of the harmlessness of the residual materials. These are the alum and the alum phosphate powders. It is true that only small amounts of alum may be in a form capable of being dissolved by the digestive fluids, yet, on the other hand, we know of the harmful effects of large quantities of soluble aluminum salts. These salts have the power of interfering with the processes of digestion, and while there is no certain knowledge that the small amounts present in bread and biscuit made with alum baking powders will produce harm, yet the preponderance of opinion of experts is unfavorable to their use.

See table of analysis on following pages.

Vinegar.

It is a fact that most of our citizens pay little attention to the nature of the vinegar they use. Vinegar is usually purchased not only as a material for rendering other foods sour, but quite as much for the fine flavor possessed by the better grades. In this country preference is generally given to the vinegar made from apple cider,

and it is supposed that such vinegar is what we usually get in stores. So highly esteemed is the cider vinegar that it commands a distinctly higher price, and vinegars from other sources are made to imitate it as nearly as possible.

But on inquiry in this state it developed, to our great surprise, that to the ordinary consumer vinegar was vinegar, no matter what its source, and that there was very rarely a call for a cider vinegar as such. As a matter of fact, there is little pure cider vinegar on sale in this state, but much imitation cider vinegar is sold in its stead. So far as the strength of the vinegars is concerned, there is little to complain of, the standard of from 4 to 5 per cent. acid required in other states being usually found.

The practice of one firm of manufacturers is most reprehensible, and calls for severe condemnation. Sample jugs of apple cider of excellent quality are sent out by Wallace and Gregory Bros., of Paducah Kentucky, and a totally different vinegar is sent in the large packages, even though the same quality was promised the retailer. This was the experience of at least one of our retail grocers, the Gary Bros., of Bozeman.

The Use of Preservatives.

The question of the continued use of the small quantities of antiseptics which are present in so many foods is an important one. There is no doubt that these antiseptics prevent, to a greater or less degree, the digestion of foods, and anything that hinders digestion is hardly desirable in food. It is entirely likely that a strong person may use repeatedly food containing such adulterants, but if so it is because his powers of digestion are sufficiently great to overcome their inhibitory effect. With persons of weak digestive power, foods so preserved can hardly prove other than harmful. On the whole, it seems only fair that we should know exactly what we are eating, and that we should be in a position to avoid that which is harmful. In this connection the testimony given before the Senate Committee on Manufactures is pertinent to the discussion. This will be found in the report previously referred to.

Occurrence of Salicylic Acid in Fruits.

For the past twelve months or more tests for Salicylic acid in fresh fruits have been carried on in the laboratory of the Montana Experiment Station with the result of showing its almost constant presence in extremely small quantity.

So far as we know the only similar work has been done by Portes and Desmouliere (Journal de Pharmacie et de Chimie, t. XIV, p. 342) who report its presence to the extent of a milligram to the kilogram of strawberries.

Desmouliere in his Doctorate Thesis in the Universite de Paris also reports its presence in raspberries, mulberries and liquorice root. (Journal de Parmacie et de Chimie, t. 16, p. 86). This so

far as we know covers all the work done outside this laboratory on fresh fruit.

It is probable that the acid is present as the methyl salt, which is well known in the oil of wintergreen, though we have not yet taken steps to prove this.

Among the fruits from which we have obtained the salicylic acid reaction are the following: strawberries, raspberries both red and black, blackberries, currants, plums, black cherries, apricots, peaches Concord grapes, crab apples, standard apples, quinces and oranges.

In a few instances we have made this work quantitative with the following results:

Currants 0.57 mgms. acid per kilo of fruit.
Cherries 0.46 mgms. acid per kilo of fruit.
Plums 0.28 mgms. acid per kilo of fruit.
Crab apples 0.24 mgms. acid per kilo of fruit.
Grapes 0.32 mgms. acid per kilo of fruit.

These values, however, are not absolute but only comparative and represent the amount we have succeeded in extracting in each case. We distilled the fruit with phosphoric acid, extracted the distillate with ether, took up with a small amount of water and applied the ferric chloride test after the ether had evaporated. Check analyses were made with known amounts of salicylic acid and showed that not nearly all the acid was extracted by this method.

We have also found the salicylic acid reaction to be given by tomatoes, cauliflower and string beans.

It seems to us that the bearing of this work is very important, particularly as regards the investigations of food chemists. While these very small quantities may not react to the tests for salicylic acid as usually applied, especially in view of the small amount of material generally worked upon, 25 grams, yet a knowledge of its wide spread distribution may save reporting on occasion materials as adulterated to which salicylic acid has not been added. Knowing that salicylic acid may occur in many of the substances either a quantitative determination will be necessary in each case or it will be well to report only on strong reactions.

We were led to this investigation by the protest of a well-known reputable firm in whose currant jelly we reported salicylic acid but which was present in apparently no greater quantity than we have since found it in the fresh currants. A similar experience was had lately in one of the state laboratories for food control.

In addition to the above work we are also studying the distribution of benzoic acid in fruit and vegetables and hope to be able to publish our results within the year.

My thanks are especially due to Mr. Edmund Burke, assistant chemist, upon whom most of the analytical work fell, and also to Mr. Irvin Cockrill, who, while a post-graduate student, carried on the work upon the vinegars and baking powders.

CANNED BEANS FOUND ADULTERATED.

Laboratory No.	Name of Brand.	Name of Manufacturer.	Where Manufactured.	Adulterant
1609	Oval Brand String Beans	A. Booth Packing Co.	Baltimore Md.	Benzoic acid
1611	Shield Brand String Beans	J. S. Farren & Co.	Baltimore Md.	Salicylic Acid

CANNED BEANS NOT FOUND ADULTERATED.

1581	Magnet Brand Stringless Beans	Isaac Robinson	Baltimore, Md.
1588	Gopher Brand String Beans	Foley Bros. & Kelley Mer. Co.	St. Paul. Minn.
1604	Jumbo Brand Stringless Beans	Miller Bros. & Co.	Baltimore Md.
1605	Peerless Brand String Beans	The C. H. Pearson Packing Co.	Baltimore Md.
1608	Club House Brand String Beans	Franklin MacVeagh & Co.	Chicago, Ill.

CANNED PEAS NOT FOUND ADULTERATED.

1519	Green Island Brand Peas	Green Island Packing Co.	Green Bay, Wis.
1525	Monarch Brand Peas	Reid, Murdoch & Co.	Chicago, Ill.
1603	Fort Snelling Brand Peas	Foley Bros. & Kelley Mer. Co.	St. Paul, Minn.
1606	Club House Brand Peas	Franklin MacVeagh & Co.	Chicago, Ill.
1582	Petits Pois Extras Fins "Le Soiel Malines" (Peas)	Fabrique International	France
1583	Petits Pois Tres Fins (Peas)	Delory	Lorient, France

CANNED CORN NOT FOUND ADULTERATED.

1259	Leopard Brand Corn	George R. Newell & Co.	St. Paul, Minn.
1505	Diamond Brand Sugar Corn	Atlantic Canning Co.	Atlantic, Iowa
1523	Extra Sweet Corn	Reid, Murdoch & Co.	Chicago, Ill.
1590	Seal Brand Standard Quality Corn	P. J. Ritter Conserve Co.	Philadelphia, Pa.
1602	Fort Snelling Brand Corn	Foley Bros. & Kelley Mer. Co.	St. Paul, Minn.
1607	Club House Brand Extra Corn	Franklin MacVeagh & Co.	Chicago, Ill.
1615	Honey Drop Sugar Corn	Davis Baxter & Co.	Portland, Me.

SOUPS FOUND ADULTERATED.

Lab. No.	Name of Brand.	Name of Manufacturer.	Where Manufactured.	Preservative.
1348	Huckin's Terrapin Soup	J. H. W. Huckins & Co.	Boston, Mass	Salicylic acid
1586	Van Camp's Concentrated Vegetable Soup	The Van Camp Packing Co	Indianapolis, Ind	Salicylic acid
1599	Van Camp's Concentrated Mock Turtle Soup	The Van Camp Packing Co	Indianapolis, Ind	Salicylic acid
1600	Van Camp's Concentrated Ox Tail Soup	The Van Camp Packing Co	Indianapolis, Ind	Salicylic acid
1613	Van Camp's Concentrated Tomato Soup	The Van Camp Packing Co	Indianapolis, Ind	Salicylic acid

SOUPS NOT FOUND ADULTERATED.

Lab. No.	Name of Brand.	Name of Manufacturer.	Where Manufactured.
1347	Huckin's Green Turtle Soup—White Label	J. H. W. Huckins & Co	Boston, Mass
1360	French Bouillon.	Armour Packing Co	Kansas City, Mo
1361	Clam Broth	Franco-American Food Co.	New York
1580	French Soup, Mutton	Franco-American Food Co.	New York
1584	French Soup, Chicken	Franco-American Food Co.	New York
1587	Van Camp's Concentrated Chicken	The Van Camp Packing Co.	Indianapolis, Ind
1601	Red Letter Double Concentrated Beef Soup	The Mullen-Blackledge Co.	Indianapolis, Ind
1612	Van Camp's Concentrated Bouillon	The Van Camp Packing Co.	Indianapolis, Ind
1359	White Label Clear Consomme.	Armour Packing Co	Kansas City, Mo

CANNED TOMATOES FOUND ADULTERATED.

Lab. No.	Name of Brand.	Name of Manufacturer.	Where Manufactured.	Preservative.
1260	Casino Brand Tomatoes	Franklin MacVeagh & Co	Chicago, Ill.	Salicylic acid
1262	Home Brand Tomatoes	Griggs, Cooper & Co	St. Paul, Minn	Salicylic acid
1263	Chicago Best Quality Guaranteed Tomatoes	Steele & Wedeles Co	Chicago, Ill.	Salicylic acid
1485	Tremaine's Tomatoes	Reid, Murdoch & Co	Chicago, Ill.	Salicylic acid

CANNEDTOMATOES NOT FOUND ADULTERATED.

Lab. No.	Name of Brand.	Name of Manufacturer.	Where Manufactured.
1258	Wicomico Tomatoes	T. R. Jones	Quantico, Md
1261	Nonpareil Brand Tomatoes	Alameda Canning & Packing Co.	San Francisco, Cal
1595	Charm Brand Tomatoes	Franklin MacVeagh & Co	Chicago, Ill.
1596	Utah Brand Tomatoes	Craig Bros	Ogden, Utah
1597	Red Knight Tomatoes	N. S. Martz	Arcadie, Ind
1598	Monumental Brand Tomatoes	W. W. Taylor & Son.	Baltimore, Md
1498	Ivy Leaf Brand Tomatoes	Thos. D. Miller	Weber, Ind

ANALYSIS OF TOMATO CATSUPS.

Lab. No.	Name of Brand.	Name of Manufacturer.
1257	Snider's Home-made Catsup.....	T. A. Snider Preserve Co.............
1269	Priscilla	Franklin MacVeagh & Co ....
1363	Blue Label	Curtice Brothers Co................
1365	Tart Tomato Catsup, Standard Brand	P. J. Ritter Conserve Co.............
1366	Favorite Brand Tomato Catsup..	P. J. Ritter Conserve Co.............
1367	Shrewsbury Puree of Tomatoes..	E. C. Hazard & Co..................
1368	Eagle Brand Tomato Ketchup..	Kuner Pickle Co....................
1559	Sunny Side Ketchup	The.Tip Top Ketchup Co............
1507	Extra Tomato Catsup Monarch Brand	Reid, Murdoch & Co................
1558	Standard Tomato Catsup	Standard Packing Co................
1508	Bayle's Tomato Catsup..........	Geo. A. Bayle.......................
1494	Sweet Spiced	Gordon & Dilworth ....
1746	Old Virginia Ketchup...........	Geo. K. McMechen & Son Co.........
1977	Nail City Catsup	The West Vir. Preserving Co........
1979	Heinz Tomato Ketchup.........	H. J. Heinz Co......................

ANALYSIS OF TOMATO CATSUPS.

Where Manufactured.	Preservative.	Coloring Matter
Cincinnati, O.	Benzoic acid	Coal Tar Dye
Chicago, Ill.	Salicylic acid	Coal Tar Dye
Rochester, N Y.	Salicylic acid	Coal Tar Dye
Philadelphia, Pa.	Benzoic acid	....
Philadelphia, Pa.	Salicylic acid	Coal Tar Dye
Shrewsbury, N. J.	Salicylic Acid	Coal Tar Dye
Denver, Col.	Salicylic acid	Coal Tar Dye
Chicago, Ill.	Benzoic acid	Coal Tar Dye
Cincinnati, O.	Acid Sulphite	Coal Tar Dye
St Louis, Mo	Salicylic acid	Coal Tar Dye
St Louis, Mo	Acid Sulphite	....
New York, N.Y.	Benzoic acid	Coal Tar Dye
Wheeling, W. Va.	Sulphite	Coal Tar Dye
....	Sal'c acid and Sulphite	Coal Tar Dye
Pittsburg, Pa.	Benzoic acid	....

JAMS, JELLIES, AND PRESERVES, ALL ADULTERATED.

Lab. No.	Name of Brand.	Name of Manufacturer.
1265	Eagle Jam, Grape Compound....	Anderson Preserving Co.............
1266	Eagle Jam, Pineapple Compound.	Anderson Preserving Co.............
1268	Eagle Jam, Raspberry Compound	Anderson Preserving Co.............
1481	Queen Black Raspberry Jam....	Franklin MacVeagh & Co...........
1482	Queen Blackberry Jam..........	Franklin MacVeagh & Co...........
1483	Queen Strawberry Jam..........	Franklin MacVeagh & Co...........
1486	Queen Red Raspberry Jam......	Franklin MacVeagh & Co...........
1487	Queen Apricot Jam.............	Franklin MacVeagh & Co...........
1488	Queen Green Gage Jam.........	Franklin MacVeagh & Co...........
1489	Queen Currant Jam.............	Franklin MacVeagh & Co...........
1490	Queen Cherry Jam..............	Franklin MacVeagh & Co...........
1491	Queen Peach Jam	Franklin MacVeagh & Co...........
1495	Queen Pineapple Jam	Franklin MacVeagh & Co...........
1496	Queen Gooseberry Jam..........	Franklin MacVeagh & Co...........
1497	Queen Pear Jam...............	Franklin MacVeagh & Co...........
1522	Extra Grated Pineapple.........	Reid, Murdoch & Co...............
1552	Pure Fruit Jam, Blackberry.....	Reid, Murdoch & Co...............
1553	Genesee Fresh Fruit Jam, Currant	Batavia Preserving Co..............
1585	Gopher Brand Preserved Strawberries.......................	Foley Bros. & Kelly Mer. Co.........
1615	D. & B. Brand, Extra Quality, Raspberry Preserves	Dodson-Brown Mfg. Co..............
1616	D. & B. Brand Strawberry Preserves	Dodson-Brown Mfg. Co..............
1617	*Red Currant Jelly	Gordon & Dilworth.................
1618	Extra Quality Blackberry Jelly..	Philip J. Ritter Conserve Co.........
1619	Extra Quality Currant Jelly.....	Philip J. Ritter Conserve Co.........
1620	Favorite Brand Compound Currant Jelly....................	Philip J. Ritter Conserve Co.........
1621	Favorite Brand Compound Strawberry Jelly Flavor	Philip J. Ritter Conserve Co.........
2274	Peacock Brand Peach Jam......	Franklin MacVeagh & Co...........
2275	Peacock Brand Blackberry Jam.	Franklin MacVeagh & Co...........
2276	Peacock Brand Cherry Jam......	Franklin MacVeagh & Co...........
2277	Peacock Brand Pineapple Jam..	Franklin MacVeagh & Co...........
2278	Peacock Brand Quince Jam....	Franklin MacVeagh & Co...........
2279	Peacock Brand Black Raspberry Jam	Franklin MacVeagh & Co...........
2280	Peacock Brand Red Raspberry Jam	Franklin MacVeagh & Co...........
2281	Peacock Brand Apricot Brand..	Franklin MacVeagh & Co...........

*Contains only a small quantity of Salicylic acid which subsequent investigations have shown was probably normally present in the fresh fruit used and which could not be considered an adulterant.

JAMS, JELLIES, AND PRESERVES, ALL ADULTERATED.

Where Manufactured.	Preservative.	Coloring Matter.	Other Adulterants
Camden, N. J....	Salicylic acid	Coal Tar Dye....	Starch Paste and Glucose
Camden, N. J....	Salicylic acid.	....	Starch Paste and Glucose.
Camden, N. J....	Salicylic acid.	Coal Tar Dye...	Starch Paste and Glucose.
Chicago, Ill......	Salicylic acid..	....	Glucose ....
Chicago, Ill......	Salicylic acid.	Coal Tar Dye...	Glucose ....
Chicago, Ill......	Salicylic acid.	Coal Tar Dye....	Starch Paste and Glucose.
Chicago, Ill......	Salicylic acid.	Coal Tar Dye...	Starch Paste and Glucose.
Chicago, Ill......	Salicylic acid..	....	Glucose ....
Chicago, Ill......	Salicylic acid.	....	Glucose ....
Chicago, Ill......	Salicylic acid.	....	Starch Paste and Glucose.
Chicago, Ill......	Salicylic acid	....	Glucose ....
Chicago, Ill......	Salicylic acid.	....	Glucose ....
Chicago, Ill......	Salicylic acid.	....	Glucose ....
Chicago, Ill......	Salicylic acid.	....	Glucose ....
Chicago, Ill......	Salicylic acid.	....	Glucose ....
Chicago, Ill......	Salicylic acid	....	....
Chicago, Ill......	Salicylic acid	....	Starch Paste and Glucose.
Genesee Co. N. Y	Salicylic acid	Coal Tar Dye...	....
St. Paul, Minn..	Salicylic acid	....	....
St. Louis, Mo...	Salicylic acid	....	....
St. Louis, Mo...	Salicylic acid..	....	....
New York........	Salicylic acid.	....	....
Philadelphia......	Salicylic acid.	....	....
Philadelphia......	Salicylic acid..	....	....
Philadelphia......	Salicylic acid..	....	....
Philadelphia......	Salicylic acid.	....	....
Chicago, Ill......	Sulphite.....	....	Starch Paste............
Chicago, Ill......	Salicylic acid and Sulphite..	....	Starch Paste............
Chicago, Ill......	Sulphite.....	Coal Tar Dye...	Starch Paste............
Chicago, Ill......	Sulphite.....	....	Starch Paste............
Chicago, Ill......	Sulphite.....	....	Starch Paste............
Chicago, Ill......	Sulphite and.. Salicylic acid..	Coal Tar Dye...	Starch Paste............
Chicago, Ill......	Sulphite.....	Coal Tar Dye...	Starch Paste............
Chicago, Ill......	Sulphite.....	....	Starch Paste............

.JAMS, JELLIES, AND PRESERVES, ALL ADULTERATED.

Lab. No.	Name of Brand.	Name of Manufacturer.
1265	Eagle Jam, Grape Compound....	Anderson Preserving Co.............
1266	Eagle Jam, Pineapple Compound.	Anderson Preserving Co.............
1268	Eagle Jam, Raspberry Compound	Anderson Preserving Co.............
1481	Queen Black Raspberry Jam....	Franklin MacVeagh & Co...........
1482	Queen Blackberry Jam..........	Franklin MacVeagh & Co............
1483	Queen Strawberry Jam..........	Franklin MacVeagh & Co............
1486	Queen Red Raspberry Jam......	Franklin MacVeagh & Co............
1487	Queen Apricot Jam.............	Franklin MacVeagh & Co............
1488	Queen Green Gage Jam.........	Franklin MacVeagh & Co............
1489	Queen Currant Jam.............	Franklin MacVeagh & Co............
1490	Queen Cherry Jam..............	Franklin MacVeagh & Co............
1491	Queen Peach Jam	Franklin MacVeagh & Co............
1495	Queen Pineapple Jam	Franklin MacVeagh & Co............
1496	Queen Gooseberry Jam..........	Franklin MacVeagh & Co............
1497	Queen Pear Jam...............	Franklin MacVeagh & Co............
1522	Extra Grated Pineapple.........	Reid, Murdoch & Co................
1552	Pure Fruit Jam, Blackberry.....	Reid, Murdoch & Co...............
1553	Genesee Fresh Fruit Jam, Currant	Batavia Preserving Co..............
1585	Gopher Brand Preserved Strawberries........................	Foley Bros. & Kelly Mer. Co.........
1615	D. & B. Brand, Extra Quality, Raspberry Preserves	Dodson-Brown Mfg. Co..............
1616	D. & B. Brand Strawberry Preserves	Dodson-Brown Mfg. Co..............
1617	*Red Currant Jelly	Gordon & Dilworth..................
1618	Extra Quality Blackberry Jelly..	Philip J. Ritter Conserve Co.........
1619	Extra Quality Currant Jelly.....	Philip J. Ritter Conserve Co.........
1620	Favorite Brand Compound Currant Jelly......	Philip J. Ritter Conserve Co.........
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2274	Peacock Brand Peach Jam......	Franklin MacVeagh & Co............
2275	Peacock Brand Blackberry Jam.	Franklin MacVeagh & Co............
2276	Peacock Brand Cherry Jam......	Franklin MacVeagh & Co............
2277	Peacock Brand Pineapple Jam..	Franklin MacVeagh & Co............
2278	Peacock Brand Quince Jam....	Franklin MacVeagh & Co............
2279	Peacock Brand Black Raspberry Jam	Franklin MacVeagh & Co............
2280	Peacock Brand Red Raspberry Jam	Franklin MacVeagh & Co............
2281	Peacock Brand Apricot Brand..	Franklin MacVeagh & Co............

*Contains only a small quantity of Salicylic acid which subsequent investigations have shown was probably normally present in the fresh fruit used and which could not be considered an adulterant.

JAMS, JELLIES, AND PRESERVES, ALL ADULTERATED.

Where Manufactured.	Preservative.	Coloring Matter.	Other Adulterants
Camden, N. J.	Salicylic acid	Coal Tar Dye	Starch Paste and Glucose
Camden, N. J.	Salicylic acid.		Starch Paste and Glucose.
Camden, N. J.	Salicylic acid.	Coal Tar Dye	Starch Paste and Glucose.
Chicago, Ill	Salicylic acid.		Glucose
Chicago, Ill	Salicylic acid.	Coal Tar Dye	Glucose
Chicago, Ill	Salicylic acid.	Coal Tar Dye	Starch Paste and Glucose.
Chicago, Ill	Salicylic acid.	Coal Tar Dye	Starch Paste and Glucose.
Chicago, Ill	Salicylic acid.		Glucose
Chicago, Ill	Salicylic acid.		Glucose
Chicago, Ill	Salicylic acid.		Starch Paste and Glucose.
Chicago, Ill	Salicylic acid		Glucose
Chicago, Ill	Salicylic acid.		Glucose
Chicago, Ill	Salicylic acid.		Glucose
Chicago, Ill	Salicylic acid.		Glucose
Chicago, Ill	Salicylic acid.		Glucose
Chicago, Ill	Salicylic acid		
Chicago, Ill	Salicylic acid		Starch Paste and Glucose.
Genesee Co. N. Y	Salicylic acid	Coal Tar Dye	
St. Paul, Minn.	Salicylic acid		
St. Louis, Mo.	Salicylic acid		
St. Louis, Mo.	Salicylic acid.		
New York	Salicylic acid.		
Philadelphia	Salicylic acid.		
Philadelphia	Salicylic acid.		
Philadelphia	Salicylic acid.		
Philadelphia	Salicylic acid.		
Chicago, Ill	Sulphite		Starch Paste
Chicago, Ill	Salicylic acid and Sulphite		Starch Paste
Chicago, Ill	Sulphite	Coal Tar Dye	Starch Paste
Chicago, Ill	Sulphite		Starch Paste
Chicago, Ill	Sulphite		Starch Paste
Chicago, Ill	Sulphite and Salicylic acid.	Coal Tar Dye	Starch Paste
Chicago, Ill	Sulphite	Coal Tar Dye	Starch Paste
Chicago, Ill	Sulphite		Starch Paste

ANALYSIS OF CEREAL BREAKFAST FOODS.

Lab'y No.	Name of Article and by Whom Manufactured.	Per Cent Water	Per Cent Nitrogen	Crude Protein Per Cent	Per Cent Ash
1537	Oat Meal Wafers, Nebraska Sanitarium Sanitarium Bakery, College View, Neb	5.35	1.56	9.72	1.16
1538	Graham Crackers, Neb. Sanitarium Sanitarium Bakery, College View, Neb	5.11	1.79	11.19	1.31
1539	Whole Wheat Wafers, Neb. Sanitarium Sanitarium Bakery, College View, Neb	5.91	1.78	11.13	1.19
1540	Oat Meal Crackers, Neb. Sanitarium, SanitariumBakery, College View, Neb	4.84	1.84	11.50	1.22
1541	Granose Biscuit, Battle Creek Sanitarium Health Food Co., Battle Creek, Mich	6.96	1.86	11.63	2.36
1542	Zwieback, Battle Creek Sanitarium Health Food Co., Battle Creek, Mich..	6.66	1.92	11.90	1.49
1543	Cream Shortened Sticks, Battle Creek Sanitarium Health Food Co. Battle Creek	5.30	1.53	9.56	1.09
1533	Pillsbury's Vitos, Pillsbury-Washburn Flour Mills Co., Minn............	6.29	2.07	12.94	.94
1577	Oat Meal, Bozeman Milling Co., Mfg. by Sioux Milling Co., Sioux City, Iowa..	7.16	2.51	15.69	1.85
1527	Rolled Avena, The American Cereal Co., F. Schumacher Mills, Akron, Ohio..	6.64	2.36	14.75	2.16
1528	Rolled White Pure Quaker Oats, American Cereal Co., Chicago, Ill.......	6.66	2.27	14.19	1.86
1532	Hornby's Oat Meal, The H.-O. Co., Clover Mills, Buffalo, N. Y............	8.31	2.39	14.94	1.84
1534	Buckeye Rolled Oats, American Cereal Co., Chicago, Ill..................	6.83	2.27	14.19	1.97
1576	White Corn Meal, Sioux Milling Co., Sioux City, Iowa...................	10.21	1.22	7.63	.73
1526	Granose Flakes, Battle Creek Sanitarium Health Food Co., Battle Creek, Mich	10.08	2.33	15.56	3.35
1529	Wheat Gluten, Battle Creek Sanitarium Health Food Co., Battle Creek, Mich	5.25	2.71	16.95	.97
1531	Wheatena; Health Food Co., New York City..............................	6.55	2.21	13.81	1.81
1535	Shredded Whole Wheat Biscuit, The Shredded Wheat Co., Worcester, Mass	6.25	1.79	11.18	1.66
1559	Granola, Sanitarium Bakery, College View, Nebraska....................	4.95	2.31	14.44	1.72
1560	Ralston Health Club Barley Food, Purina Mills, St. Louis, Mo...........	7.82	2.01	12.56	1.62
1561	Grape Nuts, Postum Cereal Co., Battle Creek, Mich......................	3.62	1.89	11.81	2.07
1562	Cracked Wheat, American Cereal Co., Chicago, Ill.......................	7.38	1.48	9.25	1.87
1563	Flaked Oat Food, Pillsbury-Washburn Co., Minneapolis, Minn............	4.94	2.30	14.38	2.02
1564	Granut, Battle Creek Sanitarium Health Food Co., Battle Creek, Mich.....	5.14	1.46	9.13	.24
1565	Pettijohn's Breakfast Food, AmericanCereal Co., Chicago, Ill............	7.51	1.70	10.63	1.87
1567	Rice Flakes, Lauhoff Bros., Detroit, Mich...............................	6.48	1.26	7.88	.47
1568	Wheatine, Empire Milling Co., San Francisco, Cal.......................	7.92	1.65	10.31	1.84
1569	Cream of Wheat, Cream of Wheat Co., Minneapolis, Minn..................	8.10	1.87	11.69	.56
1570	Sioux Wheat Flakes, Sioux Milling Co., Sioux City, Iowa.................	8.20	1.61	10.06	1.66
1571	Ralston Health Breakfast Food, Purina Mills, St. Louis, Mo.............	7.71	1.68	10.50	1.01

ANALYSES OF BAKING POWDERS.

CREAM OF TARTAR POWDERS.

Lab'y No.	Name of Brand.	Name of Manufacturer.	Where Manufactured.	Filler	Available Carbonic Acid Gas	*Volume Carbonic Acid Gas	Value Terms cts per lb.	Price per pound
1273	Schilling's Best	A. Schilling & Co.	San Francisco, Cal.	None	14.65	163.5	.40	.40
1274	Price's Cream	Price Baking Powder Co.	Chicago, Ill.	Starch.	13.70	155.5	.37	....
1272	Golden Gate	S. A. Folger & Co.	San Francisco, Cal.	None	12.84	150.4	.35	....
1650	Royal	Royal Baking Powder Co.	New York City, N. Y.	Starch.	12.63	142.4	.34	....
1651	Club House	Franklin MacVeagh & Co.	Chicago, Ill.	Starch.	9.55	107.7	.26	....
1652	Monarch	Reid, Murdoch & Co.	Chicago, Ill.	Starch.	11.16	125.8	.30	.35
	ALUM POWDERS							
1653	Home	Home Baking Powder Co.	San Francisco, Cal.	Starch.	7.75	87.0	....	.16
	ALUM-PHOSPHATE POWDERS.							
1654	Calumet	Cal. Baking Powder Co.	Chicago, Ill	Starch.	11.29	127.25	....	.35
1655	Chapman	Chapman & Smith Co.	Chicago, Ill	Starch.	7.25	83.9	....	....
1656	K. C.	Jacques Manufacturing Co.	Chicago, Kansas City, O.	Starch.	9.58	107.9	....	.16
1657	Mountain Top	Courtney & Co.	Butte, Mont.	Starch.	6.55	73.9	....	....
1658	Palace	McCormick, Behnke & Co.	St. Paul, Minn.	Starch.	6.27	69.6	....	....
1660	Perfect	Perfect Baking Powder Co	St. Louis, Mo.	Starch.	5.41	61.	....	....
1661	Silver Queen	A. Booth	Butte, Mont.	Starch.	4.15	46.8	....	....
	PHOSPHATE AND SULPHATE POWDERS.							
1662	Snowdrift	R. C. Wallace & Co.	Helena, Mont.	Starch.	11.13	127.5	....	....

*Volume of gas liberated from one ounce of baking powder calculated to the normal pressure existing at Bozeman and to the temperature of 70 degrees Fahrenheit.

TABLE OF FLOUR ANALYSIS.

Lab'y No.	Brand.	Miller and Town.	Moisture.	Nitrogen per cent.	Crude Protein per cent
1174	XXXX	Big Timber M. Co. B. T.	9.55	1.72	10.75
1173	Royal	Bozeman M. Co., Bozeman	10.05	1.92	12.00
97	Economy	Bozeman M. Co., Bozeman	10.00	1.55	9.69
102	Ceretana	Bozeman M. Co., Bozeman	10.03	2.38	14.87
100	Pillsbury's Best	Pillsbury Washburn Co., Minneapolis	9.05	2.20	13.75
98	Saskatchewan	N. Story & Co., Bozeman	10.28	2.00	12.50
99	Montana Belle	N. Story & Co., Bozeman	10.31	1.60	10.00
113	Occidental	Bozeman Milling Co.	10.00	2.48	15.50
114	Ceretana	Bozeman Milling Co.	10.51	2.14	13.38
115	Gilt Edge	Bozeman Milling Co.	10.17	2.42	15.13
116	Electric Light	Bozeman Milling Co.	10.21	2.37	14.81
117	Choice.	Bozeman Milling Co.	10.35	2.35	14.69
119	Royal	Bozeman Milling Co.	10.11	2.50	15.63
120	Best	Bozeman Milling Co.	9.75	2.14	13.34
1612	Sun Fancy Patent	Bonner Milling Co., Bonner, Mont.	10.94	1.70	10.63
1613	Star Clear	Bonner Milling Co., Bonner, Mont.	10.68	1.76	11.00
1616	Rose Straight	Bonner Milling Co., Bonner, Mont.	11.38	1.81	11.31
1575	Whole Wheat Flour	Bozeman Milling Co.	9.56	1.41	8.81

BAKED BEANS FOUND ADULTERATED.

Lab'y No.	Name of Brand.	Name of Manufacturer.	Where Manufactured.	Preservative.
1267	Rex Pork and Beans with Tomato Sauce	Cudahy Canning Co.	South Omaha, Neb.	Salicylic
1358	Heinz's Baked Beans with Tomato Sauce	H. J. Heinz & Co.	Pittsburg, Pa.	Salicylic
1493	Monarch Tomato Picnic Sauce Baked Beans	Reid, Murdoch & Co.	Chicago, Ill.	Salicylic
1521	Choice Selected Beans with Tomato Sauce	H. J. Heinz & Co.	Pittsburg, U. S. A.	Salicylic
1364	Club House Brand Baked Beans	Franklin, MacVeagh & Co	Chicago, Ill.	Salycylic
1362	Boston Baked Beans	Grocers Packing Co.	Boston, Mass.	Salicylic

BAKED BEANS NOT FOUND ADULTERATED.

1484	Pork and Beans	Franklin MacVeagh & Co.	Chicago, Ill.
1501	Sanitarium Brand Nut Seasoned Baked Beans with Tomato Sauce	Sanitarium Health Food Co.	Battle Creek, Mich.
1502	Sanitarium Brand Nut Seasoned Baked Beans with Tomato Sauce	Sanitarium Health Food Co	Battle Creek, Mich.

ANALYSIS OF VINEGARS.

Lab'y. No.	Manufacturer.	Place of Manufacture,	Selling Price Per Gal.	Sulphates	Chlorides	Coloring Matter
1623	F. C. Johnson..........	Kishwaukee, Ill..	$ .50	None.	None.	None....
1624	F. C. Johnson..........	Kishwaukee, Ill..	.50	Trace	None.	None....
1625	F. C. Johnson..........	Kishwaukee, Ill..	.50	None.	Trace	None....
1626	F. C. Johnson..........	Kishwaukee, Ill..	.50	Trace	None.	None....
1627	H. J. Heinz & Co.......	Pittsburg, Pa....	.60	Trace	Trace	None....
1628	Smith Refining Works..	Council Bluffs, Ia	.40	None.	None.	Caramel.
1629	Smith Refining Works..	Council Bluffs, Ia	.35	None.	None.	Caramel.
1630	A. Steinhorst..........	Kansas City, Kas	*	Trace	None.	Caramel.
1631	Could not obtain.......	Did not know ...	.40	None.	None.	Caramel.
1632	Sour Cider.........	Helena..Mont. ..	.40	None.	None.	None....
1633	Cross & Blackwell.....	Vienna and Phila	1.80	Trace	None.	Caramel.
1634	Wallace & Gregory Bros.	Paducah,Ky.	.60	None.	None.	Caramel.
1635	Wallace & Gregory Bros.	Paducah,Ky.	.40	None.	None.	Caramel.
1636	Wallace & Gregory Bros.	Paducah,Ky.	.40	None.	None.	Caramel.
1637	Wallace & Gregory Bros.	Paducah,Ky.	.80	None.	None.	Caramel.
1638	Wallace & Gregory Bros.	Paducah,Ky.	.50	Trace	None.	Caramel.
1639	Wallace & Gregory Bros.	Paducah,Ky.	.40	None.	None.	Caramel.
1640	Wallace & Gregory Bros.	Paduacn,Ky.	.35	None.	None.	Caramel.
1641	Wallace & Gregory Bros.	Paducah,Ky.	......	Trace	None.	Caramel.
1642	Wallace & Gregory Bros.	Paducah,Ky.	.50	Trace	Trace	Caramel.
1643	Wallace & Gregory Bros.	Paducah,Ky.	.60	Trace	None.	Caramel.
1644	Wallace & Gregory Bros.	Paducah,Ky.	.40	None.	None.	Caramel.
1645	Wallace & Gregory Bros.	Paducah,Ky.	.35	None.	None.	Caramel.
1646	Wallace & Gregory Bros.	Paducah,Ky.	......	None.	None.	None....
1647	Wallace & Gregory Bros.	Paducah,Ky.	......	None.	None.	None....
1648	F. C. Johnson..........	Kishwaukee, Ill..	......	None.	None.	None....
1649	Wallace & Gregory Bros. (Sample Jugs)......	Paducah,Ky.	......	Trace	None.	None....

*Refused.

ANALYSIS OF VINEGARS.

Per cent Solids	Per Cent Ash	Ash Alk. or Neut.	Flame.	Sold as—	Per cent Acetic Acid.	Remarks.
1.9	.258	Alk.	Pot.......	Cider Vin.....	5.55	Is an apple cider vinegar.....
2.92	.46	Alk.	Pot.......	Ap. Cider Vin.	5.15	Is an apple cider vinegar.....
2.23	.26	Alk.	Pot.......	Cider Vin.....	3.20	Is diluted apple cider vinegar.
2.90	.44	Alk.	Pot.......	Cider Vin.....	5.55	Is an apple cider vinegar.....
.16	.039	Alk.	Pot. & Sod.	Pickling Vin..	5.45	Is a malt vinegar.............
.351	.021	Alk.	Pot. & Sod.	Common Vin	8.00	Probably an acid vinegar.....
.88	.052	Alk.	Pot. & Sod.	Weakened Vin	4.75	Probably an acid vinegar.....
.26	.065	Alk.	Pot. & Sod.	Cider Vin.....	6.50	Probably a malt vinegar......
.23	.055	Alk.	Pot. & Sod.	Cider Vin.....	3.67	Probably a malt vinegar......
2.78	.46	Alk.	Pot.......	Not Sold.....	1.40	An apple cider vinegar......
3.05	.28	Alk.	Pot. & Sod.	Malt.........	4.95	Sold in qt. bot. pure malt vin.
.39	.035	Alk.	Pot. & Sod.	Cider Vin.....	7.88	Without doubt a malt vinegar.
.169	.038	Alk.	Pot. & Sod.	Cider Vin.....	2.35	Without doubt a malt vinegar.
.38	.063	Alk.	Pot. & Sod.	Cider Vin.....	4.90	Without doubt a malt vinegar.
.33	.068	Alk.	Pot. & Sod.	Cider Vin.....	9.00	Without doubt a malt vinegar.
.27	.075	Alk.	Pot. & Sod.	Cider Vin.....	5.20	Without doubt a malt vinegar.
.239	.018	Alk.	Pot. & Sod.	Cider Vin.....	7.25	Without doubt a malt vinegar.
.176	.014	Alk.	Pot. & Sod.	Cider Vin.....	4.47	Without doubt a malt vinegar.
1.00	.23	Alk.	Pot. & Sod.	Cider Vin.....	4.70	Without doubt a malt vinegar.
.68	.29	Alk.	Pot. & Sod.	Cider Vin.....	3.82	Without doubt a malt vinegar.
.306	.054	Alk.	Pot. & Sod.	Ap. Cider Vin	4.47	Without doubt a malt vinegar.
.25	.029	Alk.	Pot. & Sod.	Ap. Cider Vin	4.65	Without doubt a malt vinegar.
.19	.021	Alk.	Pot. & Sod.	Ap. Cider Vin	5.20	Without doubt a malt vinegar.
.21	.017	Alk.	Pot. & Sod.	White Wine V.	8.90	Probably made from glucose. .
.14	.027	Alk.	Pot. & Sod.	White Wine V.	4.12	Probably made from glucose..
1.47	.50	Alk.	Pot.......	Ap. Cider Vin	5.62	An apple cider vinegar.......
2.30	.32	Alk.	Pot.......	Ap. Cider Vin	4.62	An apple cider vinegar.

MISCELLANEOUS FOODS FOUND ADULTERATED.

	Name of Brand.	Name of Manufacturer.	Where Manufact'd	Preservative.
1316	Veal Loaf	Libby, McNeil & Libby	Chicago, Ill.	Boric Acid
1317	Durkee's Salad Dressing	E. R. Durkee & Co	New York	Salicylic
1318	Deviled Crab	Tangier Packing Co.	Crisfield, Md.	Boric Acid
1319	Deviled Ham	Underwood Co.	Boston, Mass.	Boric Acid
1350	Canned Corned Beef	Libby, McNeil & Co	Chicago, Ill.	Boric Acid
1436	Gold Brand Sweet Potatoes	Batesville Canning Co	Batesville, Miss.	Salicylic
1499	Breck's Grape Juice	F. A. Breck	Vineland, N. J.	Salicylic
1594	Monarch Brand, Extra Salmon	Reid, Murdoch & Co	Chicago, Ill.	Boric Acid

MISCELLANEOUS FOODS NOT FOUND ADULTERATED.

1264	Oysters, Best Quality	Steele-Wedeles Co.	Chicago, Ill.
1349	Yacht Club Salad Dressing	Tildesley & Co	Chicago, Ill.
1492	Eagle Condensed Minced Meat	Franklin, MacVeagh & Co	C..cago, Ill.
1500	Unfermented Grape Juice	Sanitarium Health Food Co.	Battle Creek, Mich
1510	Pioneer Brand, Minced Sea Clam	Sea Beach Pickling Works	Warrenton, Oregon
1520	Nuttose	Sanitas Nut Food Co, Sid	Battle Creek, Mich
1524	Monarch Brand Extra Oysters	Reid, Murdoch & Co	Chicago, Ill.
1589	Gopher Brand Extra Selected Succotash	Foley Bros. & Kelley Mer. Co	St. Paul, Minn
1591	Club House Brand Extra Selected Oysters	Franklin, MacVeagh & Co	Chicago, Ill.

BULLETIN No. 39.

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

Sheep Feeding in Montana.

Bozeman, Montana, November, 1902.

REPUBLICAN,
Bozeman, Montana,
1902.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

BOZEMAN, - MONTANA.

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MONTANA EXPERIMENT STATION,

Bozeman, Montana.

Notice.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

BULLETIN NO. 39. - - NOVEMBER, 1902.

Sheep Feeding in Montana.

By R. S. SHAW.

The agricultural conditions in Montana have now reached that stage of development whereby the state can rival the greatest feeding states of the Union, for within our own borders are to be found the sheep, hay, grain, water, climatic conditions, and men of enterprise to develop the industry. Montana now leads the states of the Union in numbers of sheep, the census of 1900 reporting 6,170.483 within her borders. Valleys, which ten years ago produced little or no hay, except some timothy or wild hay, are to-day furnishing thousands upon thousands of tons of legumes, especially suited to the fattening of sheep. The climatic conditions are such as to render the fattening process rapid and economical. Sufficient grain can be produced to give the meat products a good finish. The feasibility of shipping these finished products to the great markets has been successfully demonstrated

Suitability of Range Types of Sheep for Fattening.

The range sheep was bred primarily for wool production, though during later years an attempt has been made to improve their mutton qualities. These attempts at improvement along the latter line will no doubt result in the establishment of a dual purpose sheep, probably through the use of Rambouillet or Delaine rams on the native stocks. Experience has already taught many of our sheepmen that the heavy mutton breeds, such as the Downs, will not answer on the range. Because, therefore, of the peculiar range conditions our feeders will have to be content with a dual type of sheep rather than a special mutton type for feeding. Tests have shown that there is little difference in the returns secured from the two types. Recent experiments at this Station showed that where the mutton type lambs produced 100 pounds increase in live weight at a cost of $4.39, requiring 8.74 pounds of food to produce a pound of gain, those of the dual purpose or range type produced 100 pounds increase at a cost of $4.62, requiring 9.07 pounds of food per pound gain. These figures show the range sheep to be not far behind the special type in mutton production, while they excel them in wool production under range conditions.

Profits from Sheep Feeding.

In Station tests of 1900, 11.8 pounds of clover were required to maintain a sheep and produce one pound of gain. At this rate one ton of clover produced 169.5 pounds of mutton worth $4.68 per cwt. This gave a return of $7.93 per ton of the clover fed, while the local price was only $5.00 per ton in the stack. In 1900 the net profits per head from the Station fed lambs was 81 cents, when clover was valued at $6.00 per ton, oats at 90 cents per cwt. and damaged wheat at 40 cents per cwt. In 1901 a carload of Station lambs fed in five divisions on different rations, hence lacking in uniformity, netted a profit of 30 cents per head in Chicago when placed on the extremely poor market of March, 1901. In this case clover was valued at $5.00 per ton, grain 85 cents per cwt., and screenings at 55 cents per cwt. In 1902 Station fattened sheep gave the following profits on the Chicago market:

55 lambs, net profit of $95.15, or $1.73 per head.
51 one-year wethers, net profit of $71.70, or $1.40 per head.
52 two-year wethers, net profit of $83.44, or $1.57 per head.
53 aged ewes, net profit of $1.00, or 1.8 cts. per head.
Clover was valued at $5.00 per ton and grain at 90 cents per cwt.

Cost of Producing Mutton in Montana.

Where legumes are used phenomenal results have been secured as regards amount of food required to produce a pound of mutton and the cost of the same. In Station tests of 1900, 6.38 pounds of clover and 2.8 pounds of wheat produced a pound of mutton at 3.22 cents, with clover worth $6.00 per ton and damaged wheat 40 cents per cwt. At the same time 11.8 pounds of clover produced a pound gain, costing 3.54 cents, and 6.10 pounds of clover and 2.65 pounds of oats produced a pound of gain, costing 4.39 cents, oats being worth 90 cents per cwt. Station tests of 1901 gave the following results:

Cost per 100 pounds increase from clover, barley and oats, $4.34.
Cost per 100 pounds increase from clover and screenings, $3.34.
Cost per 100 pounds increase from clover alone, $3.53.

In Station tests, 1902, one pound increase was produced at the following cost with sheep of different ages, viz.: Lambs 4.18 cents, one-year wethers 5.83 cents, two-year wethers 5.90 cents, and aged ewes 6.78 cents; clover was worth $5.00 per ton and grain 90 cents per cwt.

As the prices charged for foods are far above the cost price, a secondary profit is secured from all the foods fed. These prices are far in excess of those charged for feed in eastern trials, where cheap grains are secured.

Shipping vs. Local Markets.

The individual feeder should never rely on local markets. Their consuming capacity is so small that much difficulty is experienced in disposing of even less than a carload lot. In March, 1900, when lambs were worth $6.50 to $7.00 per cwt. in Chicago, a portion of a carload of Station lambs had to be disposed of at $4.68 per cwt. on a local

market. The profits of 1901 and 1902 given above were secured, the former on the poorest and the latter on the best market for some years. The feeder should always select sheep in even carload lots with a view of shipping.

Cost of Shipping.

Fat sheep and cattle have both been shipped from the Gallatin Valley to eastern and western markets, the cost being about the same in both cases.

In 1901 the cost of marketing lambs shipped from Bozeman to Chicago, a distance of about 1,400 miles, including all expenses, was 83 cents per head.

In 1902 the following expenses were incurred in marketing sheep of different ages, viz: lambs 78 cents, one-year wethers $1.07, two-year wethers $1.27 and aged ewes 94 cents, the whole lot averaging $1.01 per head. In this latter case the cost is a little high owing to a prolonged stop-over.

Shrinkage in Marketing.

In 1901 the shrinkage of Station lambs between Bozeman and Chicago was eight pounds each. Over the same route in 1902 lambs shrunk 7.6 pounds, or 8.7 per cent. One-year wethers shrunk 10.4 pounds, or 8.7 per cent, two-year wethers shrunk 12 pounds, or 8.5 per cent, and aged ewes shrunk 12.2 pounds, or 11.3 per cent. In both cases the sheep were fed in the morning with access to water and weighed between 2 and 3 o'clock p. m. before shipping in the evening.

Method of Feeding and Equipment.

The beginner should start with not more than one or two carloads until every feature of the business becomes familiar. Except in careful hands the large enterprise undertaken suddenly, without proper equipment, is likely to result in failure.

Equipment.

Small yards or enclosures are very essential. Sheep will not fatten well when allowed too much liberty to roam at will. The size of feeding yards will have to be determined by the extent of the feeding. In general the fewer sheep that are run together the better the results. The average farmer, who probably will not attempt to feed to exceed 2,000 per year, should figure on dividing these up in three or four lots, grading them according to size, condition and strength. The rations can then be so adjusted as to turn out the whole band in uniform condition of fatness. It is very essential to select high, dry feed yards, through which running water passes near one end if possible. Some kind of wire netting makes good fencing, with a few strands of barbed wire encircling the top of the outer enclosure to prevent the access of dogs or wild animals. Some form of shelter should be provided, though the same may not be used more than a few days throughout the entire season. On the Station farm a shed 16x64 feet was found to be sufficient to provide shelter for 220 sheep, giving each about five square feet of ground space. The shed is eight feet high on one side and six on the other; it is enclosed with rough lumber and covered with an under layer of brush and an upper one of straw. Such a structure provides suitable protection except in time of rain in the late spring.

A suitable form of hay rack is very essential. Those used at the Station in the past few years have given excellent results. They are 16 feet long, 3½ feet high and 3 feet wide. The bottom board is 12 inches and the feeding space above is 8 inches in width. Above the feeding space three 1x6 inch boards are used. A rack of this style will furnish feeding space for thirty lambs.

Feeding.

Hay should not be supplied more than twice each day, and once may be preferable, furnishing only that amount which will be well cleaned up. In case of very coarse fodder the rough leavings should be removed; if forced to consume them the gains of the sheep will be reduced. Feeding on the ground is wasteful and unsatisfactory.

GRAIN. Only a light grain ration is necessary to produce a good finish with the legumes available; from one-half to three-quarters of a pound of grain per head per day, along with alfalfa or clover, will be sufficient to give the desired finish, if fed throughout a period extending from seventy to ninety days The grain ration should be extended throughout the whole feeding period rather than the latter half, as has been practiced in some localities. The grain may be supplied in troughs fastened to the posts enclosing each feed lot. V-shaped troughs are desirable to prevent sheep from jumping up and standing in them. Unground grain will answer well for sheep with sound teeth.

SALT. Should be in constant supply so that the sheep can secure it at will.

Gleaning Grain Fields.

The cheapest and most rapid gains are secured from sheep while running on grain and clover stubble after harvest and before the feeding season begins. In 1901 225 lambs which pastured on 112 acres of the Station farm for thirty days before going on feed, made an average increase in live weight of 9.78 pounds. The most profitable way to fatten aged ewes is by running them on clover and grain stubble during the entire autumn season.

Comparative Feeding Value of Alfalfa, Red and Alsike Clover.

MONTANA STATION BULLETIN NO. 21.

The sheep feeding industry of Montana is based on the production of legumes. Almost without exception every valley in the state, possessed of water supplies for irrigation, can be made to grow one or more of the legumes mentioned, depending upon the peculiarity of the soil, and soil moisture conditions, Some portions of the state, as the Yellowstone valley, are pre-eminently suited to the growth of alfalfa; while in others, such as the Gallatin, conditions well suited to all three legumes are found in various sections. Because of the fact that these three crops are coming into common use a test was made to de-

termine their relative values, with the followlng result, as reported in Bulletin No. 21.

Composition of the legumes used, furnished from analyses by Dr· F. W. Traphagen, Station Chemist.

	ALSIKE PER CENT.	RED CLOVER PER CENT.	ALFALFA PER CENT
Water	6.05	5.16	5.09
Crude Protein	13	12.37	12.37
Ether Extract	3.07	5.29	4.07
N. Free Extract	38.71	45.84	39.82
Crude Fibre	29.45	22.65	31.10
Ash	9.72	7.55	8.79

The comparative data secured were as follows:

16 lambs receiving alsike gained 405 pounds in 84 days.

16 lambs receiving red clover gained 402 pounds in 84 days.

16 lambs receiving alfalfa gained 377 pounds in 84 days.

Alsike clover consumed per pound increase, 6.32 lbs.

Red clover consumed per pound increase 6.43 lbs.

Alfalfa consumed per pound increase 6.58 lbs.

In this test both grain and root rations were fed along with the legumes. in like manner and amount. The results are in keeping with the protein content of the food stuffs, alsike being the highest by .63 of one per cent. In those cases where similar tests have been made in other states alfalfa has been reported about 2 per cent higher in protein contents than the clover. We conclude from this test that the feeding values of the three legumes are little different because of the greater yields obtained from the alfalfa, as compared with the clovers. The percentage of waste resulting from coarse inedible stems was least from the alsike and greatest from the alfalfa.

Fattening Lambs on Clover with and without Grain.

MONTANA STATION BULLETIN NO. 27.

Three lots of twenty lambs each were fed for ninety days, one on

clover only, the second on clover and wheat, and the third on clover and oats. Clover was worth $6.00 per ton, damaged wheat 40c. per cwt. and oats 90c. per cwt. She damaged wheat was used in order to compare the financial result from expensive and inexpensive grain rations. The results were as follows:

Gain per head per month from feeding clover and wheat,	10 pounds.
Gain " " " " " " " only,	8.1 pounds
Gain " " " " " " " and oats,	10.58 pounds.

Food required per pound gain with clover and wheat, clover	6.38 lbs.
wheat	2.8 lbs.
Food required per pound gain with clover only, clover	11.8 lbs.
Food required per pound gain with clover and oats, clover	6.10 lbs.
oats	2.65 lbs.

Cost per 100 pounds increase from feeding clover and damaged wheat, $3.22.

Cost per 100 pounds increase from feeding clover only,	$3.54
Cost per 100 pounds increase from feeding clover and oats,	$4.39

The conclusions drawn were: (1) That unmarketable wheat fed to sheep along with clover produces good gains at low cost. (2) That while fairly good gains can be secured from feeding lambs on clover alone, some grain is required to impart a good finish for shipping. (3) High priced marketable grains render the cost of production too great without increasing the live weight sufficiently to justify their use. (4) Light grain rations are sufficient where legumes are fed. In both instances quoted above only .93 lbs. grain was fed per head per day throughout ninety days

Grain Versus Screenings For Fattening Lambs.

MONTANA STATION BULLETIN No. 31.

Two lots of lambs of 53 each were fed for eighty-eight days, one

on clover and marketable oats and barley, the other on clover and second mill screenings. The clover was valued at $5.00 per ton, the mixture of oats and barley at 85 cents per cwt. and the screenings at 55 cents per cwt. The following results were secured:

Gain per head per month from feeding clover, barley and oats, 8.5 lbs
Gain " " " " clover and screenings, 9.5 lbs

Food required per pound gain with clover. and grain, clover, 5.5 lbs
grain, 1.07 lbs.

Food required per pound gain with clover and screenings,
clover, 5 lbs.
screenings, .94 lbs.

Cost per 100 pounds increase from feeding clover and grain, $4.34

Cost per 100 pounds increase from feeding clover and screenings, $3.34

The results from feeding clover and screenings indicate both greater gain in live weight and much greater economy in production than where grains were used. This is no doubt due to the variety afforded by the screenings which are relished by the fattening sheep.

Clover Versus Grain Hay for Fattening Lambs.

MONTANA STATION BULLETIN NO. 31.

Two lots of lambs of 53 each were fed for 60 days, one on clover only, the other on grain hay. The grain hay was made from a mixed sowing of spring wheat, oats, barley and peas in equal amounts, cut while in the dough stage. Both foods were valued at $5.00 per ton.

The gain per head per month from the clover was 7 pounds.

The gain per head per month from the grain hay was 5.34 pounds.

The clover required to produce a pound of gain was 14 pounds.

The grain hay required to produce a pound of gain was 18 pounds.

Cost per 100 pounds increase from feeding clover, $3.63.

Cost per 100 pounds increase for feeding grain hay, $4.60.

There was a large waste from feeding grain hay consisting of coarse cereal stems. We concluded that it was better suited to cattle than sheep.

Effect of Water Supply on Fattening Lambs.

MONTANA STATION BULLETIN NO. 31.

Seventeen lambs were selected and fed clover and screenings in the same manner as the pen of 53 heretofore described except that the former were turned to water but once a day while the latter had constant access to it.

The gain per head per month from the lambs with access to water was 9.5 pounds.

The gain per head per month from the lambs watered once a day was 7.15 pounds.

Cost of 100 pounds increase from lambs with access to water, $3.34.

Cost of 100 pounds increase from lambs with restricted water supply, $4.51.

While range stock may be able to subsist for long periods without water, these facts emphasize strongly the urgent necessity for a constant supply of good pure water for the fattening lamb.

Comparative Results from Feeding Lambs, 1-year Wethers, 2-year Wethers and Aged Ewes.

MONTANA STATION BULLETIN NO. 35.

Four lots of typical range sheep were procured and fed 88 days The foods, water, surroundings and methods of feeding were the same in all cases.

Prices Paid and Weights when Test Began.

55 lambs, $1.62 per head, average weight 62.9 pounds.

51 one-year wethers, $2.50 per head, average weight 94.9 pounds.

53 two-year wethers, $2.65 per head, average weight 115.7 pounds.

53 ewes, $2.50 per head, average weight 91.6 pounds.

Average Amount of Food Consumed per Head per Day.

Lambs, clover 2.05 pounds, barley .68 pounds, total 2.73 pounds.

One-year wethers, clover 3.77 pounds, barley .68 pounds, total 4.45 pounds.

Two-year wethers, clover 4.05 pounds, barley .68 pounds, total 4.73 pounds.

Aged ewes, clover 2.33 pounds, barley .68 pounds, total 3.01 pounds.

The total amount of food consumed by the lambs is rather small, but their ration contained a greater percentage of grain than those of the older sheep.

Relation of Grain to Coarse Food.

The lamb ration consisted of 24 per cent grain.

The one-year wether ration consisted of 15 per cent grain.

The two-year wether ration consisted of 14 per cent grain.

The ewe ration consisted of 22 per cent grain.

These differences in the percentage of grain were necessary to give the various lots uniform finish when slaughtered. The heaviest grain ration was furnished the lambs to give their growthy increase fatness; this was not considered so necessary in the case of the more mature wethers, whose increase in weight is largely fat.

Increase in Live Weight during Eighty-Eight Days.

Lambs, 23.7 pounds, percentage increase 37.7 per cent.

One-year wethers, 23.5 pounds, percentage increase 24.7 per cent.

Two-year wethers, 24.3 pounds, percentage increase 20.9 per cent.

Aged ewes, 15.6 pounds, percentage increase 17.0 per cent.

The comparative gains are strikingly brought out in the percentage increase.

Relative Cost of Production.

Lambs, cost per 100 pounds increase, $4.18.

One-year wethers, cost per 100 pounds increase, $5.83.

Two-year wethers, cost per 100 pounds increase, $5.90.

Aged ewes, cost per 100 pounds increase, $6.78.

While the lamb and ewe rations contained the same foods in about the same proportions, the wether rations contained much less grain.

Food Required for Maintenance and per Pound Increase.

Lambs, dry food consumed per pound increase, 10.16 pounds.

One-year wethers, dry food consumed per pound increase, 16.6 pounds.

Two-year wethers, dry food consumed per pound increase, 17.1 pounds.

Aged ewes, dry food consumed per pound increase, 17.5 pounds.

These amounts are larger than they would have been had more grain been used in the ration as heretofore indicated.

Slaughter Test Report (By Swift & Co.).

55 lambs, average 79 pounds, price $6.80, dress 54.2 per cent.

51 one-year wethers, average 108 pounds, price $5.85, dress 52.9 per cent.

53 two-year wethers, average 123 pounds price $5.40, dress 53.5 per cent.

53 ewes, average 95 pounds, price $4.75, dress 50.6 per cent.

"We consider all of these sheep a useful class of stock, not too fat, and they are dressed about 2 per cent above the average, coming to the Chicago market at the present time."

The percentage of dressed weight is figured on a basis of actual weight immediately after killing, shrunk 3 per cent. which is about what mutton will shrink after hanging over night.

BULLETIN No. 40,

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

ROOT CROPS IN MONTANA.

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Montana Experiment Station.

BULLETIN NO. 40. - - NOVEMBER, 1902.

ROOT CROPS IN MONTANA

By R. S. SHAW

While root crops have hitherto been grown in small quantities only in Montana, there is nevertheless a useful place for them. The old grazing system and the more recent work of production of grains are rapidly giving way to a diversified farming as the cultivated areas are being extended and tilled in a more progressive manner. Field roots will hereafter play an important part in the stock feeding operations of the farmer, for even though it has been clearly demonstrated that beets can be successfully produced for sugar making, there are no manufacturing plants in the state to use them for this purpose and such may not be made accessible to the majority of farmers in the state for some time to come. Our plan, therefore, is to discuss the question from the stock-growers' standpoint.

We take the ground that farmers that are so situated should raise small areas of roots each season for winter feeding; for such work can be conducted on every farm in Montana where grain, legumes and roots can be grown. The growth of large areas of root crops is at present not recommended and in fact should be discouraged for the reasons, that in general we are not prepared to handle, house and dispose of large crops It is a good plan to start with from one-half to one acre and this area can be enlarged to suit the demand. Already some objections have been raised against the growing of roots in Montana, such as, high price of labor and amount of work involved and lack of storage facilities. The cost of production and many difficulties pertaining thereto can be easily overcome by making use of the proper methods of culture and harvesting for our conditions; it is these we propose discussing more fully.

Value and Use of Root Crops.

Proof has already been secured which demonstrates clearly the usefulness of mangolds, carrots, sugar beets, turnips and rutabagas under our farm conditions. There is no class of stock kept on the ranch during the winter which can not be made to use some one, two or more of these to good advantage. In most cases it may not be well to grow all five kinds, as some are better suited for certain purposes. The kind or kinds grown must be governed somewhat by the soil and climatic conditions and the class of live stock to which they are to be fed. For the horse, carrots are pre-eminently suitable; for the dairy cow, mangolds, carrots and sugar beets; for the beef steer and the sheep all are suitable; for the pig, mangolds, carrots and sugar beets; for the chicken, mangolds only. This classification of general utility is based upon the use of roots in the raw condition.

The advantages derived from the use of field roots in feeding live stock is due rather to a secondary action than to the actual amount of nutriment supplied by them. During the winter season when dry foods only are available they furnish a succulent adjunct which acts as a tonic, stimulating digestion, increasing the flow of milk and causing a great saving in the more expensive grain foods. Station tests

here as well as elsewhere have proved that roots and grain form a more economical ration for pigs than grain only; that the increase in live weight is relatively greater, the cost of production less and the quality of the meat of a higher grade. The comparative feeding values will be discussed in another publication.

Conditions in Montana are Suited to Root Crops.

Though the soil and climatic conditions are extremely variable, there is scarcely a single cultivated portion of the state under irrigation where one or more varieties of field roots cannot be grown, from the lowest point up to an altitude of several thousand feet. Abundant proof of this assertion has been secured by the Experiment Station in regard to the sugar beet which has been almost universally produced in the state with satisfactory results from a sugar making standpoint; of the several classes of roots it is probably the most difficult to produce. The mangold cannot be produced with best results at high altitudes where the growing season is short; the greater part of its growth being above ground with a sparse covering of leaves the flesh, which is covered with a thin skin, is easily damaged by early frosts. If frozen the roots do not keep well during the winter. The other four classes are not so readily injured by frost and all grow late in the season. In some sections particularly where the soil is clayey or where the growth is retarded by lack of moisture, both turnips and rutabagas are seriously damaged by the green aphis, the ravages of which are much worse some seasons than others. Of the whole number carrots have been less liable to the ravages of insect pests, though mangolds and sugar beets are seldom attacked. As yet plant diseases of a fungoid nature are entirely unknown among root crops in Montana.

Soils Suitable for Root Crops.

While these differ slightly for the several classes and will be discussed more specifically later, in general, the heavier loams are best suited. Heavy clays are not suitable in any case and humus or muck soils are productive of quantity rather than quality. While the best

results will be secured from clay and sandy loams containing some humus the yields will decrease as the soils become sandy or gravelly both through lack of plant food and the inability of these soils to retain moisture. The land chosen should be so located that water can be applied just when needed; it should also be as nearly level as possible with just sufficient fall for irrigation. Where the fall is too great with the system of furrow irrigation used, there is much washing of the soil and resulting injury to the crop.

Preparation of Soil.

In this there will be some slight differences according to the climatic conditions, soil, and the crop to be grown. In all cases deep plowing must precede the crop and in some cases this must be in the spring and in others in the fall. In those portions of the state where the soil is somewhat heavy, where there is a large amount of snowfall followed by copious spring rains and where as a result the ground is impacted, then spring plowing will be necessary in certain seasons but under these conditious light porous soils should be fall plowed. Hard, dry, impenetrable soils produce prongy roots which are particularly objectionable in the case of the sugar beet. Throughout the more arid sections with scant snowfall and spring rain the ground should be plowed deep in the fall and may also be cultiuated some at that time. In preparing the seed bed some form of cultivator should be used which will cut deep and leave an even surface, this should be followed by a smoothing harrow to level the ground and bring the lumps to the surface. If the ground is too loose or lumpy it should be rolled before seeding. After this the ground is ready for marking and sowing. Where only a small area is sown it will be better to mark off the drills in order to have them straight and a uniform distance apart which not only adds to the appearance but renders cultivation and irrigation more easy and less liable to injure the crops. A marker may be constructed as follows: Cut several wooden runners about eighteen inches long out of one by eight-inch boards and round them off at one end in about the same shape as a sleigh runner; this rounded edge should also be brought to a wedge shape. These runners are then fastened together, side by side, the distance apart which the rows are required

by nailing two 1x6 inch strips across the tops. A light strip is then attached to the centre of the marker by which it can be drawn. With a marker of this kind five or six feet in width an acre of ground can be marked off in an hour or two. The runners can be changed so as to suit the requirements as to distance in marking for any of the root crops or potatoes. This method is suggested for small areas only, larger areas should be marked and planted by a seeder for the purpose.

Seeding.

Where large areas are to be grown year after year, a regular root drill should be secured. In the case of mangolds or sugar beets, the seeds of which are large, the sowing may be performed with an ordinary grain drill by stopping up some tubes to give the rows a proper distance apart. But where only small areas are planted the work can be well done with a good hand seeder of which the Planet Junior is a fair type. Using one of these a man can sow one acre of sugar beets, with rows two feet apart, in from three to four hours. These planters can be adjusted to sow all kinds of field roots and garden seeds as well. Every farmer who plants a garden should use one. The methods of cultivation and irrigation required by the various root crops will be left till these are discussed individually.

Harvesting.

The labor required and the cost of this operation are among the strongest arguments urged against the production of root crops. If the practice of hand pulling is followed much hard work and expenditure are required. The plan followed at the Experiment Station has been the following: The first operation in harvesting consists in removing the top. This can be rapidly and easily accomplished with a sharp hoe, the work being done nearly as fast as a man can walk. It is most easily accomplished in the case of the rutabaga, the top of which is supported on a neck. With practice and the exercise of proper care all classes of roots can be topped in this manner. Exception may be urged in the case of the mangold, as it has been considered necessary to twist the tops off in preference to cutting the root,

which renders them more liable to decompose. While this is true in humid climates, it does not hold good under our arid conditions, In the case of sugar beets to be used for manufacture it is desirable that a portion of the crown be removed with the top.

The next operation in harvesting consists in plowing the roots out. The deep rooted crops, such as mangolds, sugar beets and carrots, can not be overturned in many cases, owing to the depth which the plow would need to go. In such cases our practice is to plow a deep furrow away from the roots and so close up to the row that the roots are left exposed. They can then be thrown into piles or gathered in a wagon. In doing this work only one row at a time can be removed, or two when working from both sides of the patch. If a number of rows were plowed before removing the outer ones these may be partially covered when the rows are close together. Both mangolds and rutabagas can be plowed out. The draught should be so arranged as to cause the plow to cut a V shaped furrow directly under the roots. As these two crops grow on the surface so little earth is moved by the plow that a whole field can be plowed out at once. If care is taken not to plow too deep the roots will be left exposed. In all cases a plow cutting not wider than ten inches will give the best results. Some form of garden plow will answer well. For large crops a sugar beet harvester should be used.

Storing

The most satisfactory and permanent results in storing are to be secured from a root cellar built in an excavation, the object being to get below ground for security against frost. Storage houses for roots and potatoes are not as satisfactory and are expensive. The walls surrounding an excavated cellar, where there is little exposure to the atmosphere and its weathering influences, can be made of concrete, which is a cheap form of wall, as cobble stones for the structure can be found on nearly every farm and aside from the amount of lime and cement required there is little expense except for the labor, which in most cases can be performed by the farmer during seasons when work is least pressing. One of the main objects to be considered in a case

of this kind is ventilation; the climatic conditions are such that the protective qualities of a root house are not put to the extreme test except during a few cold spells of short duration. Throughout the balance of the time the necessary ventilation should be available so that the temperature may be kept as near 32 degrees without freezing. which will give the best results. Owing to the dryness of the air it has been found that our root crops will keep much better in storage where some dirt is carried in along with them, such as may adhere in harvesting. This is particularly true of sugar beets. The earth should not, however, be allowed to become packed as might occur underneath a window or the drop where roots are shoveled in, for in this case they would heat and rot. In storing root crops high temperatures must be avoided.

Pitting may also be resorted to, but is not so satisfactory as a cellar. Under such conditions the continuous use of roots for feeding is interfered with during the extremely cold spells as some days the pit would have to remain closed to prevent the access of frost. In constructing a pit, a high, well drained piece of ground should be chosen. The roots should be piled in long piles, the bottom of the pile about four feet wide, with the sides sloping upward, to meet at a point 3½ feet above the center of the pile; the length of the pit can be governed by the conditions. As soon as roots are piled cover them with a layer of about three inches of straw. free from chaff; then cover the straw with earth taken up from near the edges of the pit in such a way as to form a ditch around the same for drainage. Early in the season not more than an inch or two of earth should be placed on the straw, but later, as cold weather approaches, double the amount of earth, and prevent freezing in future by coverings of manure, used in such quantity as the severity of the weather may require. Where the conditions are extreme, or for potatoes, a double covering may be used as follows: First cover with straw and then with a thin layer of earth, which is allowed to freeze, then follow with another layer of straw and more earth. In this method a dead air space is maintained and the roots or potatoes enclosed are not effected by fluctuations in temperature from without. In extreme weather a manure covering would be needed as in the first case.

Sugar Beets.

Practical demonstrations prove that beets can be produced in Montana for sugar production quite as successfully as anywhere in the world; this is true both as regards quality and yield. As there are no factories for the production of beet sugar in the state at present, and as this publication is being prepared more especially for the stockman and farmer who may be interested in feeding problems, the following data relating to culture will apply more specifically to the production of these roots for feeding purposes.

(1) NATURE OF GROWTH.

The sugar beet is particularly characterized as a deep grower, producing a long conical tap root extending on the average from twelve to fifteen inches deep. When properly planted and cultivated, this growth should be almost entirely beneath the surface of the ground; because of this and the additional fact that the top consists of spreading short stemmed leaves, these plants are not injured by the earlier frosts.

(2) SOILS BEST SUITED.

On suitable soils with proper conditions sugar beets can be grown from sea level up to an altitude of 5,000 feet, but a short season is a disadvantage. Stiff clay soils should be avoided, and humus and muck soils, while not suited to the growth of the best quality of beets for sugar making, can be used where stock food is being produced. Sandy loams are preferable, but any rich loam will answer. The soil should be deep, as the presence of hardpan too near the surface causes prongy roots. Under semi-arid conditions, when poor soils are used, requiring farmyard manure, this should always be applied with the preceding crop.

(3) PREPARATION OF SEED BED.

In general, the plowing should be deep and done in the fall except under those local conditions where heavy snows or spring rains solidify the ground, then it should be replowed in the spring and thoroughly cultivated to reduce it to fineness and render it retentive of moisture.

Spring plowing should be done early and followed by cultivation at intervals, till sowing time and preparation completed as heretofore described.

(4) PLANTING.

In this the time will depend on local conditions, of which we have an endless variety; but in general the planting should be done as early as the working of the soil and the climatic conditions will permit. The rows should not be more than two feet apart; a less distance is recommended in growing beets for sugar making but for the purpose given two feet will answer well, providing more room for cultivation. The rows should be laid out in such a manner that a fall of not more than three-fourths of an inch to the rod will be given; if the fall is greater the tendency will be to wash the soil from between the rows, leaving the minute roots exposed and injuring the plants. Large areas should be sown with a regular drill but smaller ones with a garden seeder. Not less than twelve pounds of seed should be used per acre, in order to insure a perfect stand. If the soil is moist plant the seed three-quarters of an inch deep; if dry, one and one-quarter inches or even a little more.

(5) CULTIVATION.

If a heavy loam should bake as the result of a dashing rain, the plants may be prevented from coming through. In extreme cases only, where the crop is thus endangered, a very light harrowing may save it, if done as soon as the ground is dry and before the plants reach the surface; this should only be attempted in extreme cases. For small areas of an acre or so, cultivation by means of a hand wheel hoe should be given as soon as the plants are all nicely through the ground; adjust the wheel hoe with the two-knife attachment made to run one on each side and close up against the row. This prompt cultivation will prevent evaporation and save much future labor by destroying the young weeds. The remaining portions of the spaces between the rows may be left for horse cultivation later. The wheel hoe can be used before such time as a horse could follow the row and also avoids the danger of covering the small plants with a horse cultivator. Subsequent cultivation should be fre-

quent, deep at first and shallower as the season advances. Thin the plants to eight inches apart in the row when the second pair of leaves appear and when about two inches high, without drawing the earth away from the plant; later thinning is both more injurious and difficult. In the thinning the interspaces can be cleared by means of a hoe and the remaining bunches thinned by hand. Where the plants are not too thick the work can all be done by a hoe in the hands of an expert. The more the hands are used in thinning the more it becomes a necessity. If the beets are properly thinned and the weeds all removed from the row at the same time subsequent use of the hoe will be very little required. Do the work well the first time.

IRRIGATION.

Preparations for this are made at the same time cultivation is being given. By attaching a v-shaped point to the centre of the rear shank of the cultivator a small scratch or furrow is left to lead the water, and the smaller this is the better providing it answers the purpose without overflowing. Flooding should always be avoided with care. The amount of irrigation will depend on the local precipitation, some localities requiring one, others two and still others three applications. The indications of need of water are the turning dark green of the top leaves and the wilting of the lower ones. The water should be allowed to run till the earth between the furrows all turns dark from saturation when it should be promptly turned off. Cultivate lightly as soon as ground is dry enough after irrigation to prevent evaporation.

Sugar beets may be irrigated up to within six weeks of harvesting. They should not be harvested while frozen. Though humus or muck soils and those containing some alkali produce beets of a poor quality for sugar making, this need not deter the farmer producing them for stock food.

Mangolds.

These are admirably adapted to all classes of live stock but are especially valued for milch cows as they can be freely used without danger of tainting the milk. As a winter food for fowls none other

can replace them when fed raw. Mangolds are of several varieties differing in color as red, orange and yellow: and also in shape. as oblong or globular. The long varieties usually give much larger yields.

(1) NATURE OF GROWTH.

The mangold is particularly characterized by an upward tendency of growth so that when mature a large portion of the root is exposed. The leaves are more sensitive to frost than the sugar beet and the same is also true of the root which is covered by a very thin skin.

(2) SOILS BEST SUITED.

These are all deep soils rich in organic matter. Clay loams, strong sandy loams, and dark prairie soils are especially adapted, while stiff clays and light sands are less suitable.

(3) PREPARATION OF SEED BED.

In general the same as for sugar beets.

(4) PLANTING.

Those methods described for the sugar beet will apply in general to the mangold also. From six to eight pounds of seed is required per acre, but the amount should be governed by suitability of the soil and conditions. The distance between the rows and also the plants in the row will vary with the variety chosen, the conditions of the soil, the earliness or lateness of sowing and the length of the growing season. The larger the variety, the richer the land, the earlier the date of seeding and the longer the season, the wider apart should be both rows and plants in the row and vice versa. Twenty-seven inches is an average distance for the rows and twelve inches for the plants in the row.

(5) CULTIVATION AND IRRIGATION.

In general the same as for sugar beets.

Carrots.

This crop can be grown with more certainty throughout the state than any other and is less liable to attacks of disease and insect pests than any other. They are equally useful for all classes of live stock

and especially for horses at that season of the year when they are deprived of succulent food, as they are greatly relished by them in the raw state.

(1) NATURE OF GROWTH.

It is such that the carrot crop is not injured by the early frosts of spring or autumn and has great power to resist drouth so that when started in the early spring a crop can be looked for with almost unfailing certainty. Crops can be produced without irrigation in those sections where there is some sub-irrigation or a fair amount of rainfall. The carrot is a deep grower, developing entirely within the ground. The varieties are classified as long, medium and short; and also by their color, as red, orange and white. The long varieties are losing favor owing to the difficulty in harvesting them.

(2) SOILS BEST SUITED

Almost any soil with a fair amount of plant food will give a good crop of carrots. The favorite soils are those of a deep loamy character, capable of retaining moisture. Some varieties are better adapted than others to shallower or heavier soils.

(3) PREPARATION OF SEED BED.

In this the work should be much the same as for sugar beets and mangolds but most of the work should be done in the autumn. The preparatory cultivation should be performed with a view to cleaning the ground from weeds. The spring cultivation should consist in preparing a fine mellow seed bed.

(4) PLANTING.

As there is little danger of injury from frost, plant as early as possible. Small areas will produce enormous yields if properly handled and these are most satisfactorily sown with a hand seeder. Eighteen inches between the rows will suffice for the crop, but twenty-four is more frequently given to facilitate the ease of horse cultivation. From two to four pounds of seed are required per acre according to the suitability of the conditions.

(5) CULTIVATION.

This should begin as soon as the young plants mark the line of the row, using the method heretofore described for mangolds and sugar beets. Prompt cultivation is more necessary in the case of the carrot as it is slow to germinate and come up, thus giving all weeds a good start. From a consideration of both quantity and quality the best results will be secured from thinning the plants to four inches apart in the row. This is the tedious and expensive operation of carrot culture as the thinning must be done entirely by hand. Where, owing to adverse conditions or poor seed the stand may be somewhat thin and irregular, a good crop may result without any thinning.

(6) IRRIGATION.

This should be performed by the method described and less water will suffice than for most other root crops.

The harvesting which has been generally regarded as a laborious and expensive operation can be quickly and easily performed by the method heretofore described and need not be done before the approach of winter.

Turnips.

These are of two varieties, viz., those of Swedish origin commonly called Swedes or rutabagas; the other class being known as Fall Turnips. The Swede turnips have the firmer flesh and are the better keepers; they are known by the purple, green or purplish green color of the top of the bulb and by the leaves which are a darker color than the fall varieties. Fall turnips vary greatly in the comparative strength of the tops and in the size, color, shape and texture of the bulbs. Turnips form an excellent food for many classes of live stock, but can not be satisfactorily fed to swine if raw, or to milch cows without danger of tainting the milk.

(1) NATURE OF GROWTH.

This is such as to especially adapt them to moist, cool climates, but they give remarkable results in Montana wherever grown under

irrigation. The greater portion of their growth is made with great rapidity in the autumn months.

(2) SOILS BEST SUITED.

Those of a free working, loamy nature are best for turnips, especially where containing some sand but not sufficient to render them poor. Rich muck soils tend to stimulate too great a growth of tops with a corresponding deficiency in root. Our valley soils, however, are well suited to the growth of the turnip.

(3) The preparation of the land should be somewhat similar to that heretofore described as being deep and thorough.

(4) PLANTING.

This may be delayed to as late as June 10th in those localities where there are late spring rains to germinate the seeds; in drier sections sowing should take place earlier. Twenty-seven inches is a suitable distance between rows and from two to four pounds of seed are required per acre. The seed may be sown with hand seeder or by means of a field drill providing the turnip seed is mixed with some kind of meal or sawdust or dry earth to give it bulk.

(5.) CULTIVATION.

Should begin early and be frequently repeated. The plants should be thinned to twelve inches apart as soon as two or three inches high. The work can all be preformed by means of a hoe, as the plants are not so liable to injury as sugar beets or mangolds.

(6). Irrigation should be practiced sufficiently often to keep the turnip plants growing vigorously. This is the most successful method of counteracting the attack of plant lice. The slow growing plants are the first to be attacked and the first to succumb.

Harvesting need not take place till late in autumn owing to the late continued growth and ability of the turnip to withstand the frost. The crop can be topped by means of a hoe and plowed out as described.

Potatoes.

The culture of potatoes must necessarily be greatly different because of the almost unlimited variety of conditions under which they are grown throughout the state. The methods considered must therefore be general rather than specific. Potatoes can be successfully grown in Montana, both with and without irrigation; in the latter case, however, only in such sections where the ground is moist from sub-irrigation or where there is more than the average precipitation.

Selection of Varieties.

These may be classed as early, medium and late, and such a schedule may be obtained from the Experiment Station at any time as all new varieties are collected for testing. In most sections above an altitude of 6000 feet, early varieties only should be grown; medium sorts between 4000 and 6000 feet; and the later kinds below 4000 feet. The yields per acre are least from the early varieties, increasing as the time for maturity extends.

Suitable Soil.

The best results, considering both quality and quantity, are to be secured from rich loams containing some sand and much humus; stiff clays, mucks and light sands are undesirable.

SELECTING SEED.

Too often the variety chosen is selected because of a large total yield with too little regard for quality. The value of a variety depends upon the percentage of marketable potatoes produced rather than from the total yield. This is ascertained by deducting the small and rough potatoes from the product of a given area. Then in addition to this the potatoes should possess good shape, viz.: an oval neither tending to flatness nor long points at either end, with the eyes set well out on the surface. From a potato possessing this shape there is less loss in preparing for cooking. Much difference of opinion exists regarding the selection of tubers for seed. The best practice, however, is to select medium sized, smooth and uniform potatoes, notwithstand-

ing the evidence which may be produced to show that equal results, in some cases, have been secured from small sets.

Treatment for Scab and Preparation for Seed.

Potatoes selected for seed should always be treated for scab whether apparently affected or not, as the parasitic spores may be present even though not visible. The preventative measures are neither laborious or expensive, and a badly infected crop is practically unmarketable. Either of the two following methods may be used:

(1) Soak the uncut seed from one and a half to two hours in a solution consisting of one pound or pint of formalin to thirty gallons of water; or (2) Immerse the tubers for the same length of time in a solution consisting of corrosive sublimate in the proportion of one ounce to seven and one-half gallons of water. The former treatment is preferred as it does not present the deadly poison properties of the latter, nor corrode metallic vessels. These methods of treatment will not be effective in replanting badly infected ground; in such cases the place of planting should be changed. The conditions seemingly favorable to the development of scab are soils possessing an abundance of decaying organic matter with an excess of moisture accompanied by proper temperature. Past experience seems to indicate that heavy manuring or plowing in green crops accompanied by excess of moisture or copious irrigation, tends to increase scabbing.

The cutting process should always follow treatment. Though a number of devices have been invented for this work, none answer so well as a knife in the hands of a skilful operator. When the tubers are large with a moderate number of eyes, cut one eye to a piece splitting the seed end. With a variety having many eyes it may be necessary to cut two to each piece. After cutting, if storm prevents planting for a number of days, spread the sets out thin on a board floor and sprinkle with dry earth or ashes to hasten the callousing of the cuts and prevent decomposition, which will soon follow if the sets are left piled or sacked. Under local conditions where spells of cold, wet weather are likely to follow early planting, uncut seed about the size of a hen's egg is safer to plant, being much more resistent to decay.

Attention should also be given to the selection of perfectly matured seed. In some localities early frosts may destroy the vines before maturity. While the immature tubers will grow quite well they are much longer in starting and making an appearance above ground. Potatoes also which have been exposed to any possibility of even slight freezing should not be used for seed.

PREPARATION OF THE SOIL

Deep plowing and thorough cultivation are essential to render the soil loose and mellow. Fall plowed land, which has settled and become hard, should always be replowed shortly before planting time.

PLANTING.

The labor involved in planting large areas will justify the purchase and use of a potato planter; any one of the several kinds on the market will do excellent work. In general the drills should be from thirty-six to forty-two inches apart with the sets twelve inches apart in the row. For small areas drill rows may be opened with a small plow and refilled with the same implement after planting. The drills should not remain open long to allow them to dry out. After covering with the plow cross harrow to level the ground; this is particularly necessary where the crop is to be irrigated. A covering of four inches with the heavier and more retentive soils is sufficient, but six inches may be needed in the lighter and drier ones.

CULTIVATION.

Harrow lightly at once as soon as the young plants begin to appear above ground to destroy weeds and retain moisture. Frequent cultivation should follow according to the conditions; the drier the season the more frequent the cultivation. More cultivation and less irrigation will produce crops of better quality.

IRRIGATION.

In this the time and amount is greatly varied by the local climatic and soil conditions. In general one irrigation can be made to suffice if proper cultivation is given and the water applied about the time the

plants come into bloom. Earlier irrigation is liable to start too many sets; delayed too long a second growth producing rough potatoes is likely to occur. Under the most extreme conditions two irrigations may be necessary. After irrigating, the ground should be cultivated lightly to prevent evaporation. The same method of irrigation as that described for sugar beets will also apply to potatoes.

HARVESTING AND STORING.

Large areas are readily harvested with a potato digger such as the Hoover. In storing, the secret of success lies in keeping the potatoes in a dark storeroom or cellar with the temperature as low as possible without permitting freezing.

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SUGAR BEETS.

THE CROP OF 1902.

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SUGAR BEETS.

The Crop of 1902.

F. W. TRAPHAGEN.

Except for the fact that very few of the cooperating farmers responded to the request to send to the Station samples of sugar beets for analysis, the results of the year's work are very satisfactory.

No general conclusions can be drawn from the analysis of such a small number of samples for the various localities, though these results, so far as they go, support the conclusions of former years.

The season has been very generally reported as having been very unfavorable to the growth of beets, yet the yields, both in quantity and quality, have been very good.

The richest lot of beets that has yet come into the laboratory was grown by W. M. Wooldridge, Valley county. Six beets raised by Mr. Wooldridge averaged 22.8 per cent sugar in the beets, equivalent to 24 per cent sugar in the juice.

Results, this year and in past years, show that the manufacturing campaign might begin as early as the middle of September, thus making a campaign of great length possible.

Excellent yields of fine beets have been obtained this year with very little water, in some cases none in fact, reaching the crop from planting until harvesting. This would indicate the possibility of its use as a dry land crop, in places where water is not available.

TABLES OF COMPOSITION, YIELD AND VALUE.

Laboratory No....	Co-operating Farmer.	Locality.	Date Analyzed	Variety
2250	J. R. Stevens	Bridger, Carbon County	September 26	Dippe
2251	F. E. Wedge	Columbia Falls, Flathead County	September 26	Hoerning
2252	Ebenezer Johnson	Fulton, Lewis & Clarke County	September 26	Vilmorin
2255	Theo. Koenig	Kalispell, Flathead County	October 17	Hoerning
2256	J. H. Green	Manhattan, Gallatin County	October 17	Strandes
2257	H. O. C. Andrews	McLeod, Sweet Grass County	October 17	Strandes
2258	J. J. Quinlan	Forsyth, Rosebud County	October 17	
2259	Fred Edelman	Sheridan, Madison County	October 26	Hoerning
2260	A. B. Leckenby	Union, Union County, Oregon	October 26	Dippe
2261	J. P. Jones	Whitehall, Jefferson County	October 26	Strandes
2262	G. Hollenbeck	Pioneer. Powell County	October 26	Vilmorin
2263	J. J. Quinlan	Forsyth, Rosebud County	October 26	Vilmorin
2264	J. R. Stevens	Bridger, Carbon County	October 26	Dippe
2265	W. M. Wooldridge	Hinsdale, Valley County	October 27	Strandes
2266	Isaac Eddy	Lothrop, Missoula County	October 27	Vilmorin
2267	H. R. Ballinger	Red Lodge, Carbon County	October 27	Dippe
2268	Mrs. B. Hauck	Garrison, Powell County	October 29	Vilmorin
2269	A. L. Halliday	Choteau, Teton County	October 29	Vilmorin
2270	A. C Gifford	Fallon, Custer County	October 29	Strandes
2274	C. M. Larkin	Bridger, Carbon County	November 5	Dippe
2275	W. E. Milnor	Troy, Flathead County	November 5	Vilmorin
2276	M. M. Fergueon	Bozeman, Gallatin County	November 5	Hoerning
2277	Lewis Krueger	Bozeman, Gallatin County	November 7	
2282	Experiment Farm	Bozeman, Gallatin County	November 7	
2283	J. B. Duggins	Ekalaka, Custer County	November 7	Dippe
2284	T. S. Proud	Kalispell, Flathead County	November 29	Strandes
2285	T. S. Proud	Kalispell, " "	November 29	Dippe
2286	T. S. Proud	Kalispell, " "	November 29	Vilmorin
2287	F. E. Wedge	Columbia Falls, Flathead County	November 29	Hoerning
2288	E. H. Ellinger	Melville, Sweet Grass County	November 29	Vilmorin

TABLES OF COMPOSITION, YIELD AND VALUE—CONTINUED.

Average Weight	Per cent sugar in juice........	Per cent sugar in Beets..........	Per cent purity....	Yield tons per acre	Pounds sugar per acre........	Return to Farmer per acre (Ohio Standard......
2 pounds 1 ounce	18.9	17.95	81.4	14	5026	$ 90.72
2 pounds 3 ounces	16.4	15.6	81.5	14	4468	79.80
1 pound 9.5 ounces	13.9	13.2	78.4	....	....	....
2 pounds 11.5 ounces	16.7	15.9	80	19.5	6201	113.10
14 ounces	15.9	15.1	82.8	20	6040	110.60
1 pound 10 ounces	16	15.2	83.3	27	8208	150.12
1 pound 10 ounces	20.4	19.4	81.2	17.5	6790	121.80
1 pound 3 ounces	17	16.2	82.9	21	6802	123.90
1 pound 7 ounces	14.2	13.5	86.6	18.8	4954	91.75
13 ounces	13.5	12.8	75.4	10	2560	47.60
12 ounces	13.8	13.1	80.2	11	2882	53.46
1 pound 7 ounces	14.4	13.7	57.6	17.5	4796	88.55
1 pound 4 ounces	18	17.1	78.6	14	4788	86.80
10.3 ounces	24	22.8	77.4	20	9120	161.80
1 pound	16.3	15.5	87.2	17.5	5425	90.05
1 pound 9 ounces	15.7	14.9	85.3	....	....	....
1 pound 15 ounces	14.6	13.9	81.6	....	....	....
1 pound	15	14.25	86.2	....	....	....
1 pound 4 ounces	17	16.15	87	31.75	10255	186.69
9 ounces	18.8	17.86	89.1	12	4286	77.40
7.5 ounces	16.9	16	83.6	....	....	....
2 pound 1 ounce	16	15.2	81.2	22	6688	122.32
14 ounces	18	17.1	80	....	....	....
1 pound	17.9	17	91.3	....	....	....
1 pound 7 ounces	18.6	17.7	80.1	....	....	....
1 pound 7 ounces	17.7	16.8	81.2	14	4704	85.40
1 pound 1 ounce	19.6	18.6	83	11	4092	73.70
1 pound 5 ounces	17.6	16.7	82.2	16	5344	96.96
1 pound	19	18	81.2	11	5040	91.00
2 pounds 8 ounces	15.5	14.7	72.4	24.6	7232	132.84

TABLES OF CULTURE NOTES.

Laboratory No....	Co-operating Farmer.	Soil	Date planted	Date Harvested	Width between rows
2250	J. R. Stevens	Clay, gumbo	April 14	September 15	16 inches
2251	F. E. Wedge	Sandy loam	May 24	September 22	18 "
2252	Ebenezer Johnson	Black loam	May 18	September 23	22 "
2255	Theo. Koenig	Black sandy loam	May 21	October 8	18 "
2256	J. H. Green	Black garden loam	May 6	October 9	16 "
2257	H. O. C. Andrews	Black soil	May 5	September 26	20 "
2258	J. J. Quinlan	Sandy loam	May 10	September 29	24 "
2259	Fred Edelman	Sandy loam	May 12	October 14	12 "
2260	A. B. Leckenby	Clay loam	April 28	October 15	20 "
2261	J. P. Jones	Sandy loam	May 20	October 16	20 "
2262	G. Hollenbeck	Black loam	May 20	October 12	18 "
2263	J. J. Quinlan	Black soil	May 5		"
2264	J. R. Stevens	Clay, gumbo	April 15	October 15	16 "
2265	W. M. Wooldridge	Sandy loam	May 1	September 20	18 "
2266	Isaac Eddy	Black loam	May 6	October 21	18 "
2267	H. R. Ballinger	Sandy	June 20	October 24	28 "
2268	Mrs. B. Hauck	Sandy loam	June 29	October 22	24 "
2269	A. L. Halladay	Sandy loam	May 16	October 25	24 "
2270	A. C. Gifford	Sandy loam	May 18	October 25	20 "
2274	C. M. Larkin	Sandy loam	May 12	November 2	16 "
2275	W. E. Milnor	Sandy loam	May 20	October 31	24 "
2276	M. M. Ferguson	Black loam	June 2	October 28	36 "
2277	Lewis Kruger				"
2282	Experiment Farm	Sandy loam			"
2283	J. B. Duggins	Sandy loam	May 29	November 3	18 "
2284	T. S. Proud	Sandy loam, very deep	May 18	November 16	18 "
2285	T. S. Proud	Sandy loam, very deep	May 18	November 15	18 "
2286	T. S. Proud	Sandy loam, very deep	May 18	November 16	18 "
2287	F. E. Wedge	Sandy loam	May 24	November 17	18 "
2288	E. H. Ellinger	Sandy loam	May 5	November 19	20 "

TABLES OF CULTURE NOTES—CONTINUED.

Irrigation.	Cultivation.	Remarks.
Frequent and plentiful.	Plowed 10 inches deep, no subsoiling.	Season unfavorable.
None.	Thinned June 28.	Season unfavorable.
None, no water from June 23, very dry	Thinned June 11.	Season unfavorable.
None, very little rain.	Plowed 7 inches deep.	
Three times, June 15, July 20, August 12.	Plowed 7 & 6 in. deep, cultivated with garden plow; thinned June 20.	Season favorable.
Twice, June 10 and July 15.	Thinned June 16.	Season unfavorable.
No irrigation and no rain.	Thinned June 15.	Season very unfavorable.
Twice, in June and in July	Plowed 8 inches deep, not su' soiled; thinned June 15.	Season favorable.
None.	Plowed 9 inches, subsoiled 4 inches, stand excellent, thinned June 2.	Season favorable.
Every 10 days after July 10.	Thinned July 10.	*Season very unfavorable.
Only during July.	Thinned June 30, hoed twice 4 inches deep; stand excellent.	Season very unfavorable.
One-half in. water to row every 10 days fr'm Jul. 5 to Aug. 25.	Thinned July 11.	
Once, June 20.	Thinned June 20.	Season favorable.
Four irrigations and several rain and hail storms	Thinned June 20, plowed 7 inches, subsoiled 7 in.; frequent cultivation.	Season unfavorable.
Irrigated twice.	Thinned July 6 to 15.	Season cold, v'ry unf'v'ble
		Season unfavorable.
Three times.	Thinned June 20.	Season unfavorable.
Water from well when watering garden.	Early in July; plowed about 6 inches; good stand.	Fair season. Frost in June.
Twice, in July and in August.	Thinned July 1.	Season very unfavorable.
None, spring wet.	Plowed 8 inches deep; thinned July 1; stand medium.	Season very unfavorable.
Once, August 6.	Thinned July 7, July 28 and Aug. 11.	Season favorable.
None.	Thinned in June.	Season unfavorable.
None.	Thinned July 12, plowed 8 inches; stand excellent.	Season unfavorable.
None.	Thinned July 10.	Very cold and backward.
None.	Thinned July 11.	Cold and backward.
None.	Thinned June 28.	Season unfavorable.
	Thinned June 20, plowed in May 10 inches deep.	Season very unfavorable.

*Seed did not come up till July 1, then not more than one-quarter of a stand.

Where beets have been allowed to remain in the ground after they have ripened they have shown a marked deterioration. This is shown in the case of samples 2250 and 2264, grown by J. R. Stevens, of Bridger, and in 2258 and 2273, grown by J. J. Quinlan, while on the other hand samples 2251 and 2287 show the opposite results, but in the latter case the ground was very dry towards the end of the season, and soon after became covered with snow.

While occasional frosts are experienced after the crop is in, the sugar beet seems to be well adapted to withstand the severity of such frosts as occur during the growing season in Montana.

The Continental Sugar Company, at Fremont, Ohio, pays $4.50 a ton for beets testing 12 per cent sugar and of a purity of 80 degrees. For each per cent of sugar above 12 in the beet an additional 33⅓ cents is paid. I have calculated, on this basis, the return our Montana farmers would receive from each acre of sugar beets planted, provided that the results obtained experimentally were also obtained on a larger scale. These figures are given in the tables.

Some of the beets have a purity of less than 80 per cent, and the farmer would not receive for these as much as the table shows. I do not know just how much is deducted for low purity, so have been unable to substract in the cases mentioned.

No averages are attempted this year because of the small number of samples analyzed.

BULLETIN NO. 42.

MONTANA

AGRICULTURAL

EXPERIMENT STATION

-- OF --

THE AGRICULTURAL COLLEGE

-- OF --

MONTANA.

THE CODLING MOTH.

BOZEMAN, MONTANA, DECEMBER, 1902.

BOZEMAN CHRONICLE--1903

MONTANA AGRICULTURAL

EXPERIMENT STATION.

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MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 42. - - - - December, 1902.

THE CODLING MOTH.

Carpocapsa pomonella Linn.

R. A. COOLEY.

Montana now has not far from 900,000 apple trees growing within her borders. Only about one-third of these have yet come into bearing and few, if any, have produced a maximum crop of fruit. Notwithstanding the newness of the industry, the production of fruit is already looked upon as one of our main branches of agriculture. There exists complete confidence in its future, and its development is being pushed forward with enthusiasm.

The fruit growers have wisely been looking into the future, and have recognized in the codling moth a serious menace to their orchards. Other insects also have been recognized as dangerous, and as a means of protection against all, a State Board of Horticulture has been created, the duty of the members of which is to prescribe regulations for inspection and disinfection of fruits and nursery stock, and otherwise afford protection.

Montana's problem with this insect is, in some particulars, a peculiar one. It has not yet gained a footing in our commercial orchards, and is present in destructive numbers in only a very few places, the most important of which is Missoula which lies at the lower end of the Bitter Root valley.

So far as the commercial orchards are concerned, the codling moth is not in Montana. The problem, then, is the one of taking the greatest possible advantage of the fortunate conditions. We

believe that by vigilance we can prevent the insect from getting into full possession of the orchards, as it has done in many parts of the country where it is necessary to use every means possible in order to get a remunerative crop of fruit. It is hoped that instead of allowing the moth to firmly establish itself and then trying to repress it, we may be able to prevent it from gaining a foothold.

The present paper aims only to discuss the moth from Montana's standpoint. We believe that every person interested in the production of Montana's principal fruit, the apple, should have an intimate knowledge of this insect which is the worst pest of the apple. Many are not familiar enough with the insect to know how serious a pest it is, and what it means to allow it to get into the orchard.

It is hoped in a future publication to give a more elaborate account of this important pest.

THE STATUS IN MONTANA.

The only cases of infestation by the codling moth in Montana, known to the writer, are here discussed.

As is now well known in the state, the moth was found to be doing considerable damage at Missoula in the summer of 1901. The situation was indeed quite serious, but since the season's work of the Experiment Station and Board of Horticulture, in co-operation, the cause for alarm has been very largely removed. Mr. Brandegee and the writer took a buggy drive up the Bitter Root valley from Missoula to Hamilton and return, for the express purpose of satisfying ourselves as to whether or not the moth is in the valley. It is very gratifying to report that we were unable to find a single example of the moth outside of Missoula.

Mr. H. C. B. Colville, while acting as inspector in the summer of 1899, located the insect at Thompson Falls. The writer is not informed as to the condition of this colony at the present time.

Mr. Brandegee reports that the pest is well established in the home yards in some parts of the city of Helena. It has been there a number of years to his knowledge, and is very destructive. He states that fully 95 per cent of the fruit in entire orchards in the residential districts was taken in 1902, but that there was only about one-half a full crop.

In August, 1900, Mr. Fred Whiteside of Kalispell sent wormy apples to the Station asking to be informed whether or not they were affected by this insect. Upon being informed that he actually had the moth in his orchard, he at once picked and destroyed all the fruit from the single tree known to be infected, and all those near by. Since that time no more moths have been seen in his orchard.

During the summer of 1902, Mr. O. C. Estey, of Bigfork, inspector for the district, found it in several localities in and near Kalispell. On August 26th he found about one-hundred wormy apples in one orchard. In two other orchards he found one and three trees respectively that were affected. We are inclined to believe the situation at Kalispell to be serious. Left to itself, the moth would sooner or later spead to the surrounding country.

ARE ANY PARTS OF MONTANA IMMUNE?

Many individuals have believed that the climatic conditions of Montana would prevent this insect from ever becoming a serious pest. Others have felt that the isolation of their orchards would make them immune. We believe that the moth is capable of becoming more or less destructive in any climate that will permit the profitable production of apples. This opinion is amply borne out by the experience of other states. Moreover, the fact that the moth has maintained itself so well in Missoula and Helena confutes any theory of immunity for places of similar climate.

It is true that widely isolated orchards may be kept free for a considerable time, perhaps indefinitely, if precautions are taken against bringing fruit boxes or other suspected material to the orchard.

THE POSSIBLE DESTRUCTIVENESS OF THE MOTH.

It is a well established fact that an insect pest is more abundant and destructive under climatic conditions favorable to its life and development, than outside of the climatic conditions to which it is adapted. The codling moth is no exception.

The United States has commonly been divided into five life zones as follows: boreal, transitional, upper sonoran, lower sonoran, and tropical. These zones are of irregular and broken outline, and extend across the continent from ocean to ocean. Three

of them cross Montana; the boreal, which includes the mountain tops; the transitional, which roughly speaking includes the agricultural valleys of the state, except those in the southeast corner, the latter being included in the upper sonoran; and the upper sonoran, which embraces the southeast corner as far north as the valley of the Yellowstone river, and west to an indefinite line in the vicinity of Big Timber.

No apples are grown in the boreal zone in Montana, and the moth is not found there. It follows, then, that all the apples grown in the state, except in the southern part, which at present are few, are in the transitional zone.

Without going into the details we may sum up the results obtained by various investigators in other states as follows: While the insect is able to maintain itself, its injuries vary in different years, and it is always less destructive than in the next warmer zone, the upper austral.

Professor Aldrich in Idaho and Professor Piper in Washington, after careful and comprehensive investigations, report that the amount of destruction varies from about 5 per cent. up to about 25 per cent.; on the other hand Professor Gillette of Colorado reports that at Fort Collins, which is in the same zone, from 35 per cent. to 70 per cent. is taken, and Professor Cordley has found that in a narrow strip of the transitional zone, near the coast in Oregon, the moth is also more injurious.

Under conditions existing in Montana it has been impossible to gather data of much value as bearing on the percentage of destruction by the moth. In the first place we were unable to go into large orchards and count the affected and clean apples as they were picked from the trees, since the only infested trees were in the home orchards of Missoula and vicinity. In the second place, such records, even if carefully kept, do not tell the whole story, since the effect of the first brood of larvae on some winter varieties, and of course on summer varieties, is to cause the apple to drop. They wither and disappear before the harvest and are therefore not taken into reckoning if the comparison be made alone on the wormy and clean fruit at the time of harvesting.

We undertook to keep an accurate record of the wormy and clean fruit in the cage at Missoula, (described later in this paper) and reached the following results:

When the first brood of larvae was coming out of the fruit we counted 323 apples on the tree and on the ground, and of these 50 were wormy. It is very probable that a few more were wormy that did not appear so at that time.

On October 5th, we again counted the fruit on the tree and on the ground, and found 144 clean and 115 wormy. All the fruit affected by the first brood of larvae dropped to the ground and disappeard. If only 50 were taken by the first brood, 273 were left. There were 259 sound and wormy apples on and under the tree on October 5th. This number subtracted from 273 leaves 14 apples which were either taken by the first brood or dropped on account of failure to mature. Because of the failure to know what became of the 14, we are defeated in our attempt to get an accurate record of the percentage of destruction. It would perhaps have been possible if we could have put in an immense amount of time and been in the cage every day. It is obvious that no one could have prepared an accurate statement of the percentage of loss by a count at the time of harvest alone, as the apples destroyed by the first brood had disappeared and only 259 apples were to be found as against 323. If we premise that the 14 apples were sound we can figure that 51 per cent. was taken by the moth. The least percentage of destruction that we can calculate therefore is 51.

There are other facts that tend to lessen the value of estimates of loss. Unless the best of judgment is used in selecting from an orchard, representative trees from which to count the fruit, the deductions made from the counts of a few trees are misleading. The actual number of apples taken by the insects in years of full crop and in years of short crop, probably does not vary much, yet in years of scarcity the loss is felt much more keenly.

The crop in Missoula this season was probably a full one.

With some misgivings we venture to state that the loss to whole orchards in the worst infested districts has been not far from 45 per cent. This is based on many extended examinations in the open as well as on the cage experiment. It must be remembered that the insects in the cage were protected against birds, and to some extent against insect enemies.

In response to a request for information of Mr. James O. Read and Mr. C. M. Allen, as to the amount of loss at Missoula in the

summer of 1901, we were informed that 60 per cent. was destroyed, but this probably applies to a few of the worst infested orchards. Enough is known to convince us that the situation is serious.

We consider birds to be great destroyers of these insects, since we have found very many cocoons from which they have removed the larvae or pupae. Therefore in the open orchards of the state where birds would be less disturbed, and where, also, there could be fewer places in which the larvae might construct their cocoons, than in the city yards where fences and other material furnish suitable protection, the loss would be much less, probably seldom, if ever, above 35 per cent. for whole orchards.

Along the valley of the Yellowstone river from Big Timber to the eastern boundary of the state, and south of this line, the moth could be very injurious. In the same zone, the upper sonoran, in the states to the west of Montana, under normal conditions, as high as 100 per cent of the apples are damaged where no protective measures are employed. Mr. C. B. Simpson has recorded* having found ten holes in a single apple, and the remains of twenty-three eggs on one apple and seventeen on another from orchards with but a little fruit. We may take these statements as indicating the possibilities of injury in the same zone in our state.

HOW THE CODLING MOTH SPREADS.

Undoubtedly the most common means of spread of the moth over long distances is in fruit packages. It is not strange that the insect has extended itself to almost every fruit growing region of the world, for when we analize horticultural and commercial practices, we find a chain of conditions almost perfectly adapted to its spread.

Along with the development of a new agricultural country, apple growing naturally follows. Young trees are brought in, planted, and cared for until they begin to produce fruit. In the meantime the public demands apples, and the merchant supplies them, making use of the surplus crops of other regions. With the imported apples are brought the insects which were in fruit as larvae when it was picked from the trees. These larvae on reach-

*Bulletin 30, New Series, Div. of Entomology, U. S. Department of Agriculture, 1902.

ing full growth crawl out of the fruit, and go in quest of a place to their liking in which to spin the cocoons which they occupy during the helpless pupa stage. The desired place is often found in an angle of the box or barrel, or under a cleat or beneath a board that has sprung in the freight car. From these points they may get to the orchard in various ways. The packages may be stored in the cellar for the winter, or until they are distributed, and the moths developing in the spring fly out of the open windows and doors and seek the fruit trees. Empty fruit packages are often thrown out behind back buildings, sometimes close by fruit trees. The writer once found an apple box in a back yard in Bozeman, and on picking it up found a number of cocoons of the codling moth in the corners. Within thirty feet was a small orchard of apple trees. The chances were favorable for the moths to colonize in the orchard.

On leaving the fruit the larva often forms its cocoon in some material entirely separate from the fruit package. The writer has found the cocoons by the hundreds in freight cars recently unloaded of fruit. We are informed by Mr. Estey of Bigfork, that the heart of the main colony of the moth in Kalispell is within 100 yards of the side track of the Great Northern railroad. It is very probable that this colony was started from a car on the track. This car might have been unloaded of its fruit in almost any state in the country and yet have been the source of infection at Kalispell for the moths would leave the car wherever it might be when warm weather had completed their development, and meantime the car may have been transferred hundreds of miles. In the commission houses of our cities, as well as in the warehouses of our grocery stores, apple boxes are often stacked up parallel with many other kinds of produce such as boxed canned goods, packages of vegetables, melons, etc. The larvae may, and doubtless do, go to these other packages to pupate.

The practice of buying empty fruit boxes of the merchants in town and taking them to the orchards to be refilled is a particularly dangerous one, since the insects if present, are taken direct to the spot where they are most to be feared.

The codling moth is not distributed on nursery stock unless it be through mere accident.

From the foregoing it naturally follows that the centers of population are the first places to contract this pest. These towns then become centers of distribution for the surrounding country. Being provided with wings the moths can spread by flight, but it is probable that by this means they do not travel far.

One moth of either sex is incapable of starting a colony, but those in one fruit box may be sufficient since a box often contains a score or more cocoons.

WHAT BESIDES THE APPLE DOES THE MOTH ATTACK?

It is well known that the apple is the principal fruit injured by the codling moth. Pears are affected, but to less extent. Crab-apples, quinces, wild haws, stone fruits, rose hips, and the screw bean, (*Strombocarpa monocca*) have also been reported by various authors, but Mr. Simpson in his paper, previously mentioned, states that upon investigation it was found that in every case of reported attack upon stone fruits, the work had been found to be that of the peach twig borer. Mr. Simpson also examined a large number of quinces and roses without finding a single case of infestation. Notwithstanding these facts it seems possible that the codling moth might lay its eggs on some other of the rosaceous fruits if unable to find any of its favorites and might possibly develop to maturity. The writer hopes to be able to give some definite information on this point in a future paper.

ANOTHER INSECT DOING SIMILAR WORK.

On August 28th, while on the trip up the valley of the Bitter Root, in company with Mr. Brandegee, as previously mentioned, the writer found a single apple in a poorly kept orchard about one mile north of Lo Lo, which upon first examination seemed to be, beyond question, affected by the codling moth. The apple was a yellow transparent and showed on its side the characteristic appearance of the entrance opening of the codling moth. Though the apple was examined closely when picked, there was not the slightest doubt in the mind of the writer that the work was that of the "apple worm." On cutting open the apple later, the appearance was entirely different from that expected. The larva had

left but had made a fine caliber burrow which was very long and tortuous and did not reach the core. It can be said with almost certainty that the work was not that of the codling moth.

DISCRIPTIONS AND LIFE-HISTORY.

The larva having completed its growth in the fall of the year, leaves the fruit and goes in search of a place in which to spin a cocoon about itself. By searching in infested orchards about the trunks of trees that bore fruit the previous season, in the crotches and under scales of bark, the cocoons may be found. To some extent, they conform to the shape of the crack or crevice in which they are placed, being often much flattened.

With their mandibles the larvae digs off pieces of bark, thereby hollowing out the cavity and using in the cocoon the bits of bark together with the threads they spin from the body. Thus the cocoon is made to conform in color to its surroundings which is doubtless some protection against natural enemies. Many cocoons are made in objects entirely foreign to the fruit trees, as in fences, old rubbish, or any other material near at hand suitable for their purpose. They have been known also to enter the soil to pupate. Some of the men employed to scrape the trees at Missoula in the spring of 1902, reported that they had found cocoons on the trunks of poplar trees near the apple trees. While there is chance for mistaken identity of the insect in this case, there is no reason why the report may not be true.

In the cocoon the insect passes the winter as a larva, changing to a pupa with the warm weather of the following spring.

THE PUPA.

The pupa is brownish in color, is five-sixteenths of an inch in length and has no appendages. After two or three weeks, when the insect is ready to emerge as a moth, it wriggles part way out of the cocoon and splits on the back. The moth crawls out leaving the empty pupa skin still protruding from the cocoon.

THE MOTH.

The moth is a beautiful little insect with the fore wings marked with many gray and brown cross lines. Dark brown spots and streaks of orange or gold occur on the posterior end of the wings. The hind legs are grayish brown. Many of the moths caught in

the orchard are very badly rubbed and do not have the markings here mentioned. There are other species, that, to one unfamiliar with insects, might be mistaken for it.

THE EGG.

The egg is not far from hemispherical in general shape but has the edges flattened out. When examined from above or obliquely it seems much flattened, and appears hemispherical only when seen in profile. It is milk white in color.

EGG LAYING.

The moths from the winter cocoons deposit the eggs which produce the first brood of larvae. The writer's observations agree with those of other persons who state that the eggs are laid both on the leaves and on the fruit. Throughout the season more eggs were found on the fruit than on the leaves.

While in Missoula, on October 4th, the writer was fortunate enough to see a moth deposit an egg on an apple. This occurred at 5:40 p. m., the sun being slightly above the horizon and shining brightly on the town. Within fifteen minutes after seeing the egg deposited, a thermometer was found and read at 68 degrees F.

The writer was approaching close to the outer and lower branches of an apple tree and saw a codling moth flying about the leaves and fruit in a very purposeful manner. An apple was selected and apparently without any regard for position on the fruit she stopped and arched the abdomen down, bringing the ovipositor against the skin. These steps were distinctly seen, but at this point the moth took fright and flew away, going one-third the way around the tree, settling down and secreting herself in a slightly curved leaf. In about one minute she started out again, of her own accord, resuming her purposeful search. She lit upon an apple and at once arose again, flying higher in the tree, still searching. As she approached an apple with the calyx end turned toward her, she lit upon it, immediately turned one-quarter way round, and backed down into the depression around the calyx till the extremities of the wings touched the opposite side. She remained motionless for about thirty seconds, and flew away to another part of the tree and continued the search. The writer climbed into the tree, picked the apple and found the freshly laid

egg in precisely the spot expected. It was about one-fourth of an inch from the calyx. The apple bearing this egg was brought to Bozeman, and lay on the writer's desk until the morning of the 16th of October, when the egg had hatched and the young larva was found crawling over the surface of the apple.

Many observers have stated that the eggs are laid at night time. We have made no observations on the point except the one above recorded. In view of what had been written we were surprised to find the moth laying so early in the evening. The sun had just left the top branches of the tree.

One egg or many may be laid on an apple. As we have already stated Mr. Simpson has found as high as 23 eggs on one fruit.

DURATION OF EGG STAGE.

Direct observations of various writers have brought out the fact that the duration of the egg stage varies with the temperature and is on an average about seven or eight days. They have been known to hatch as quickly as three days. The single egg discussed by the writer, hatched in practically eleven days; but the conditions were not normal since the egg was kept in doors.

THE LARVA.

The newly hatched larva is about one-sixteenth of an inch long, whitish in color, with the head, a shield just behind it and a shield at the posterior end of the body, black. Later in its life, the parts that were first black, become brownish.

The young larva after a short period on the surface of the apple, begins to bore into the flesh. The greater part go in at the calyx end, but many enter at the point where two apples touch or where a leaf is in contact with an apple. Others go in at the stem end, or on the exposed surface.

Judging from observations in the states to the west of Montana, the larval stage in Montana would be about 24 days. The writer has made no complete observations on this point, but can state definitely that it is less than four weeks.

The last published records of Mr. Simpson showed that an average of 83 per cent. of the first brood go into the fruit from the calyx end. From one counting at Missoula in 1902, the writer found 90 per cent. to enter at this point.

The course of the larva in the fruit is more or less familiar to all. It bores direct to the core and feeds there on the seeds and flesh, making an irregular cavity which sometimes extends some distance from the core. The filthy frass is cast out of the opening on the surface, and remains there, matted together by the silken threads, until the larva pushes it off in leaving the fruit.

The larvae of the first brood, as well as those of the second, spin cocoons in which to pupate. The cocoons constructed by the first brood larvae are said to be thinner and less substantial than those in which the larvae pass the winter. The moths produced from the first brood larvae deposit the eggs for the second brood.

THE OUT-OF-DOOR CAGE AT MISSOULA.

Realizing that a knowledge of the life-history and habits of this insect is basic to all rational measures against it, whether remedial or preventive, an attempt was made to gather all the information possible along these lines. The information gained thus far, while of considerable value, is in nowise complete. We hope to continue the studies as long as results of economic value are produced.

For the purpose of affording an opportunity for study of the habits of the moth under normal conditions in Missoula a cage was made enclosing an entire tree. This cage is twelve feet square and twelve feet high, and is constructed of medium quality of lumber and wire mosquito netting. Along the square from corner to corner a wide board was settled into the earth with the top edge exposed above the surface, to which is fastened the netting. The door shuts against packing and is held close by buttons. Outside the cage is a thirteen stranded barbed-wire fence which is angled at the top making it fairly proof against boys. The door and gate through the wire fence are kept locked.

Repeated comparison of the temperature inside and outside the cage failed to show any constant difference.

The details of the experiment and the results are mingled with the discussions that follow.

DISCUSSION ON THE NUMBER OF BROODS, ETC.

On May 31st, eighteen cocoons and two moths were placed in the cage at Missoula. The cocoons for this purpose were secured

from Professor A. B. Cordley, who kindly arranged to have his students collect them for us. We are aware that there is a possibility that the results might be considered less reliable than if the insects had been secured locally. However, it was planned to continue the experiment for a number of years and we believe that in the future the results will be reliable.

Moreover the closest examination failed to reveal any differencc in forwardness of development inside and outside the cage. In all probabilities the insects placed in the cage lay dormant until those outside began to develop, and developed parallel with them.

Missoula is 222 miles west of Bozeman on the line of the Northern Pacific railroad, and on account of the distance, trips to the cage were not very frequent, but by carefully timing the visits and by use of local assistance much information was obtained.

On June 18th one egg was found in the cage and a number more on various trees outside. Many of the moths had come out, but not all.

On July 10th, the occasion of the third visit, all the moths had emerged and three young larvae were found just beneath the skins of the apples. Eggs were fairly common. A few very badly rubbed moths were found, which, though of the correct size for the codling moth, may have been some other species. The insects were also found plentifully outside of the cage, either in the egg stage or having been in the fruit a few days.

On August 8th, 9th, and 10th, the larvae were coming out of the fruit. Some had evidently come out a few days earlier and some of what appeared to be the first brood were still in the apples. These ranged all the way from half grown to full sized larvae.

On August 11th many cocoons were found in the open orchards and about one-half of the larvae had pupated. Two empty pupa cases were found protruding from cocoons, and fresh looking adult moths. A few newly hatched larvae were seen.

We believe that about August 10th marked the beginning of the second brood of larvae.

On August 27th, insects were found in all stages, but it was noticeable that there were fewer moths and inhabited cocoons than on August 10th. As later developments show there were

many larvae in the fruit at this date but there were few outward indications. One might almost have thought that the trees were practically free from moth.

On October 5th, the appearance was very different. Many wormy apples vacated by the larvae were in evidence. The second brood of larvae had plainly left the fruit, though a few were to be found still feeding.

It was on this date, as previously stated, that the moth was seen to deposit the egg. Six other eggs were found in the same orchard this date without difficulty, and a number of moths were seen. We are inclined to consider these late moths as stragglers of the second brood.

To summarize, we may say that at Missoula in the summer of 1902 there were two broods of the codling moth and probably no more. The first brood began to go into the fruit about the 18th of June, and the second brood about August 10th.

RECOMMENDATIONS.

It would be out of place in the present paper to enter a lengthy discussion of the most approved means of combating the codling moth, for the general public is not yet called upon to employ such means.

Such protective measures as may be employed to enable us to retain our present advantage over the moth may well be considered.

It is desirable to continue the work at Missoula in order to keep at a minimum the chances of infection of the surrounding country and the valleys of the Bitter Root river and Rattlesnake creek. The situation at Kalispell should also be thoroughly looked into and as energetic means employed there as at Missoula.

We believe that since we know when the different broods begin to enter the fruit at Missoula, we can make good use of insecticides. Much advantage could be gained by again banding the trees. Much good was accomplished with bands during the past season. In this way many of the insects that escaped the poison were captured.

We recommend the use of Paris green as an insecticide with the usual addition of lime.

On August 23rd, an apple tree was selected from the Experiment Station orchard at Bozeman, and sprayed with a Bowker preparation of arsenate of lead at the rate of three pounds to fifty gallons of water, which is the strength recommended by the Bowker Insecticide Company.

The application was made personally by the writer and care was taken to spray thoroughly and yet not over spray.

At the time of fall harvesting, the apples were picked and part of them handed over to the Station chemist, Dr. F. W. Traphagen, to be tested for arsenic. Before harvesting considerable rain fell. Below is the report that Dr. Traphagen made:

PROF. R. A. COOLEY,

Montana Experiment Station, Bozeman, Mont.

DEAR SIR: Following are the results obtained in the analysis of the apples you submitted to me some time ago:

Number of apples	14
Total weight	41.5 oz.
Average weight	3.0 oz. (scant)
Total lead arsenate obtained from apples	.166 grains
Equivalent to metallic lead	.115 grains
Equivalent to arsenic oxide	.031 grains

While the amounts of poisonous substances found on these apples is not great, they are probably dangerous, from the fact that lead is a cumulative poison and that the presence in food or water of relatively smaller qualities than that present in these apples, is looked upon with grave suspicions by those who have given these questions careful consideration.

The arsenic, occurring in smaller quantities, adds also to the element of danger which would be introduced into our daily lives by using arsenate of lead for spraying apple trees under the condition of your experiment.

It seems to me that the amount remaining upon the apples could be very greatly reduced by spraying at an earlier period, when the apples were small or even when in the bud.

Experiments on spraying at different periods would seem to be indicated by results obtained in these tests.

Yours truly,

F. W. TRAPHAGEN.

The writer was somewhat surprised to get this report of possible danger from the use of arsenate of lead and we intend to make more extended investigations.

One of the advantages of arsenate of lead over Paris green, as an insecticide, is that it forms a film of the poison over the fruit and foliage that is not easily removed by rains. It has been felt that this would be particularly useful against the codling moth since the eggs hatch and the larvae evter the fruit over such a long period of time. Uniform success has attended its use in some of the eastern states.

We still feel that early spraying with arsenate of lead would be more desirable than with Paris green.

We are indebted to Professor M. J. Elrod of Missoula and Mr. H. B. Dick of Kalispell for weather records that have been of much value to us in our work.

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BULLETIN No. 43.

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

DUTY OF WATER IN MONTANA.

THIS PUBLICATION IS THE SECOND OF A SERIES OF FARMERS' BULLETINS ON IRRIGATION TOPICS.

Bozeman, Montana, January, 1903.

REPUBLICAN,
Bozeman, Montana,
1903.

MONTANA AGRICULTURAL

Experiment Station.

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Postoffice, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

MONTANA EXPERIMENT STATION,

Notice.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

BULLETIN NO. 43. - - JANUARY, 1903.

DUTY OF WATER IN MONTANA.

BY S. FORTIER.

INTRODUCTION.

This is the second of a series of farmers' bulletins on irrigation topics.

The results herein summarized, together with additional information which will appear in subsequent publications, represent the joint efforts of the Office of Experiment Stations of the Department of Agriculture and this Station. The funds required to carry on the work have been obtained from the State of Montana, the Department of Agriculture and this Experiment Station.

The general features of all the irrigation investigations conducted by this Station during the past four years have been ably planned and supervised by Professor Elwood Mead. During the past season Mr. Arthur P. Stover, an assistant under Professor Mead, was in direct charge of much of the field work. The writer desires also to acknowledge the valuable assistance rendered in both field and office by the senior students in civil engineering of the Montana Agricultural College.

DUTY OF WATER.

The word "duty" is used in a variety of ways. In irrigation it shows the relation between the amount of water used and the area of land on which it is applied. This relation may be expressed in several ways. The units most frequently used are a miner's inch of water and an acre of land. The duty of water may be high or low, depending on the quantity used on a given area. In Southern California, where water is costly, one miner's inch irrigates on an average

five acres of land. This is considered a high duty, and is rendered possible by preventing waste and in skillful use. In certain sections of Montana and the Rocky Mountain States the duty of water is only one inch per acre. This large amount of water is frequently required for new land with a dry subsoil. When, however, this amount is used on the same fields for fifteen or twenty seasons in succession, it shows that a large percentage is wasted.

The duty of water may also be expressed in cubic feet per second and acres. In 1890 the legislative assembly of Wyoming fixed the maximum amount of water that could be legally applied in irrigation in that state by providing "That no allotment shall exceed one cubic foot per second for each seventy acres of land." From 1890 to 1900 the duty of water under the Bear River Canal system in Northern Utah was one cubic foot per second for each eighty-acre tract. This duty corresponds to one Montana miner's inch for two acres.

In the opinion of the writer, there is a better way to express duty of water than by either the miner's inch or the cubic foot per second. By both of these methods one is left in doubt as to the volume actually applied. In both, the flow of the irrigation stream is assumed to be continuous, and the amount of water used will depend quite as much on the length of the irrigation season as on the size of the stream. Fifty miner's inches flowing for eighty days is equivalent in volume to one hundred miner's inches flowing for forty days. It is thus obvious that the length of the irrigation season must be fixed before the duty can be ascertained. It seldom happens that water is used for the same number of days in any two counties, or even precincts; hence the difficulty in ascertaining the duty when it is expressed in acres, per miner's inch or cubic foot. The better way, it seems to the writer, is to determine the quantity of water applied to a particular field, farm or district.

Rainfall is measured in depth over the surface on which it falls, and since irrigation is intended to supplement the natural rainfall there is no good reason why it should not be measured in a similar manner. Rain and snow are usually measured in inches, but in expressing duty of water the foot and fractions of a foot are used

instead. When the quantity of water used is stated, it is expressed either in feet over the surface or in acre-feet. An acre-foot is that amount of water which will cover an acre to the depth of one foot. In Montana the average rainfall during the crop growing season is over six inches. We will assume that twenty-four inches is added by human effort, making a total of thirty inches, or two and one-half acre-feet. This is considerably greater than the natural supply of the humid East during the summer season.

ASCERTAINING THE DUTY OF WATER.

At first thought, it seems easy to ascertain the duty of water. Only two things are necessary—the area of land irrigated and the amount of water applied. In actual practice it is not so easy. The flow of the irrigation stream, ditch or canal fluctuates—it is seldom the same for any two consecutive hours of the day. This necessitates constant observations at the place of measurement or the introduction of scientific apparatus which will record every change in volume. Then again, much depends on where the water used in irrigation is measured. If it were conveyed in a tight pipe, there would be no loss, and the amount entering the intake would correspond with that delivered at the lower end. Usually the water is conveyed in an earthen channel, and for every hundred miner's inches diverted from the natural stream, only sixty may be delivered, the remaining forty inches being lost along the route by seepage, evaporation and leakage. In the results herein given, the duty of water under the canals was found by measuring the amount of water which passed through the headgates. On each of the field tests, the water was measured as it entered the highest part of the field. The latter averaged about eighteen inches in depth over the surface, while the former averaged nearly forty-seven inches.

CONDITIONS AFFECTING DUTY OF WATER.

It is well known that the amount of water used in irrigation differs. One-half of a quarter section of land may require much more water than the other half. No two irrigated valleys within the borders

of a state have similar physical conditions, and each arid state, or territory, has its own peculiar characteristics as regards water for irrigation. In a practical publication of this kind it may not be out of place to outline briefly the chief conditions which affect the duty of water:

(1) LOSSES IN CONVEYANCE.—The quantity of water delivered to the farmers is frequently only one-half that taken from the stream. The various losses due to seepage, evaporation and leakage in the main canal and laterals cause this large reduction. The attention of the farmers of Montana is earnestly called to this fact on account of the large financial loss entailed. The writer does not wish to imply that all of this loss can be prevented, but he is convinced that a large percentage might be saved at comparatively small cost.

(2) CLIMATIC CONDITIONS.—Of these, rainfall is perhaps the most important. The average annual precipitation for Montana is between fourteen and fifteen inches. The months of greatest precipitation are April, May and June, the period when moisture is needed to mature crops. In the following tables it will be noticed that the rainfall varies from 1⅜ to 9⅛ inches and averages 5¾ inches. This amount of moisture in the case of the field tests forms on an average 30 per cent of the total amount of water applied to the crops.

In the colder arid states the season is shorter and irrigation is practiced only a short period in summer; while farther south, as for example in Arizona, water for irrigation may be used throughout three-fourths of the year. Then, too, evaporation is affected by temperature, wind, etc., and in a region of high temperatures, or hot, dry winds, or both, the consequent loss of water by evaporation is great.

(3) DIVERSIFIED FARMING.—A farmer whose cultivated crops are confined to such cereals as oats, wheat and barley cannot make the most of his water supply. Such crops may require a large amount of water from the time the plants cover the ground until the grain is well headed out, but this period is limited to from thirty to fifty days. The man who raises grain only has no further use for irrigation water during that season. When diversified crops, such as alfalfa, clover, grain, roots and fruit are grown it is possible to increase the area

without increasing the amount of water used, and so obtain a higher duty.

(4) TIME ROTATION.—The prevailing custom in several states and territories of the arid West is to apportion water by the time method instead of in continuous streams. In the case of small holdings in particular, water can be more economically used in a proper system of time rotation. The work can be better done and at less cost than where a small stream is used continuously.

(5) MANNER OF PAYING FOR WATER.—A canal corporation, which conveys water to distribute to farmers for a fixed rental usually sells a water right for a certain tract of land. The purchaser, by the terms of his contract is compelled to use his allotted share of water on the tract for which a water right has been purchased and not elsewhere. If the user were granted permission to buy water by volume from the canal company and to use it wherever he pleased a much greater economy in its use would result.

(6) JUDICIAL DECREES FOR EXCESSIVE AMOUNTS.—For the most part the volumes of water used in irrigation are unknown. As a rule few ditches or canals are measured until after the owners are threatened with litigation. Then there is great inducement for all parties concerned to try to magnify both the amount diverted and the extent of the land irrigated. When a witness does not know the capacity of a ditch, and it is to his interests to make it appear to be large, his testimony has usually a decided bias in that direction. When no reliable measurements of ditches have been made, water right cases can only be decided on the testimony submitted and this accounts for the many recorded cases in which excessive amounts have been decreed.

(7) CULTIVATION AND GRADING.—The proper cultivation of the soil is necessary, in both humid and arid climates. Cultivated plants require a finely pulverized soil. In regions deficient in rainfall, thorough cultivation serves to retain the moisture, by lessening the amount of evaporation. Grading is even more important. To irrigate land that has a rough, uneven surface, not leveled to a uniform grade, is frequently the cause of much waste of water, extra labor, small crops and eventually damaged land.

(8) KIND OF CROP.—The proper percentage of moisture in the soil does not differ much for the common cultivated plants. Some crops require more water than others but this difference is due chiefly to a longer period of growth or to the time when water is needed. Barley, for instance will mature in three and one-half months, while sugar beets require a month longer. Again it is often difficult to obtain sufficient water to irrigate root crops, vegetables and occasionally orchards. This does not arise from the fact that a larger supply is required but it is due to the time of irrigation, the last irrigation being usually applied late in the season, when the flow of natural streams is low.

(9) MANNER OF IRRIGATING—The duty of water depends to a great extent on the skill and attention of the irrigator as well as on the way it is distributed over the field. Where flooding is practiced, much depends on the location and grade of the field laterals as well as the direction of the seed drills. In Montana a large percentage of the water conveyed to the irrigated fields is wasted in the midnight hours when there is no one to look after it.

(10) CHARACTER OF THE SOIL AND SUBSOIL.—A coarse sandy or gravelly soil requires much more water than a heavy, clay soil. When the upper layer is porous and the subsoil impervious, the conditions are favorable for sub-irrigation in which case a small amount of water may irrigate a large area. On the other hand the top layer of soil may be underlaid by gravel wash. Such formations require an abundant supply of water.

(11) THE GROUND WATER LEVEL.—In some localities the water in wells will rise near the surface during the latter part of the irrigation season. This indicates that the subsoil is completely saturated and that the minimum amount of water should be applied in irrigation. To over-irrigate such tracts would result in damage to both crops and soil.

(12) THE CONFIGURATION OF THE SURFACE.—An even uniform slope, neither too steep nor too flat, is one of the most favorable conditions for the economic use of water. Tracts that are traversed by ravines or other irregular formations, are not only difficult to irrigate but the waste of water is usually considerable.

THE IMPORTANCE OF A KNOWLEDGE OF THE DUTY OF WATER.

A knowledge of the service or duty of water is necessary in all irrigated regions. It has always been regarded as one of the essentials in irrigation. As rural communities increase in population the extent of the cultivated area is also increased, new ditches are excavated and the capacities of old channels are enlarged until a time comes when the natural streams are overtaxed and disputes arise as to the rights of each claimant. Such controversies can only be settled on the amount of water required to mature crops.

The farmer knows how much seed to sow for each kind of crop. He should also know how much water to apply. Without this knowledge farming operations cannot be economically planned or carried on. The farmer who buys 100 miners' inches from a canal company, but is ignorant of how many acres this supply will irrigate is handicapped.

When farmers unite in co-operative undertakings, the location, extent and character of the land to be reclaimed are usually familiar to all. The puzzling questions to such parties are the amount of water required and the size of the ditch to convey it. The same problem confronts the officers of the large capitalistic canal. The expenditures may be large and an error in the estimate of the amount of water required may entail heavy losses.

In the near future the Federal Government will expend in all probability, several million dollars in this state on irrigation canals and storage reservoirs. In such large enterprises the area of land which a standard unit of flowing water will irrigate is one of great importance.

And finally, without a knowledge of the duty of water, it is impossible to determine equitably rights to its use. When a court, owing to a wrong conception of the quantity of water required, grants to an individual or corporation, three or four times more than he can use, it not only deprives other settlers of a much needed supply but the application of so much water tends to convert good land into bogs and marshes.

AMOUNT OF WATER USED

In all of the experiments made to ascertain the duty of water, the

results of which are herein briefly recorded, no attempt was made to control or limit the amount used. The proprietor of the field or farm, or his employe, was free to turn on as much water as he considered necessary. A part of the supply usually flowed off the field, or was otherwise wasted, but no deduction was made for this waste. The total amount entering the highest part of the field was measured by means of a trapezoidal weir or other devise and the area under crop including the space occupied by the feed ditches and laterals was surveyed in the ordinary manner. From this information the depth of water over the surface irrigated was ascertained. This depth over the surface in the 46 field tests varied from a trifle more than four inches (.35 feet) to over seventy-two inches (6.06 feet) and averaged eighteen inches or one and one-half acre-feet per acre irrigated.

In Table No. 1, the duty is expressed in acres per miner's inch. the lowest duty was at the rate of one miner's inch per acre and the highest duty was one miner's inch for 13 acres. The average of all the 46 experiments conducted on fields was at the rate of one miner's inch; for 3.7 acres. In another column of the same table the duty is expressed in acres per cubic foot per second. The average number of acres irrigated per cubic foot per second was 142.

There is much more water used per acre under the canals. In seven canals, the results of which are given in this publication, the combined area is 41466 acres and the average depth of water applied over this surface was 3.9 feet, or nearly 47 inches: Under this duty one cubic foot per second would irrigate about 80 acres and one Montana miner's inch, 2 acres.

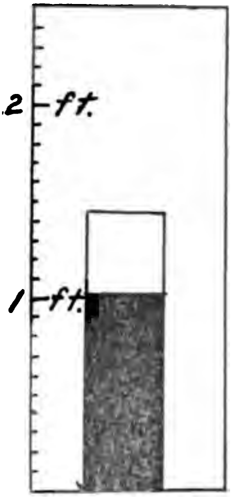
TABLES AND ILLUSTRATIONS.

Space would not permit a description of each experiment. It was necessary to state the facts in the briefest possible manner. The chief results have accordingly been presented in the form of tabulated statements. And since the main purpose of the bulletin is to show the amount of water used in irrigation it was deemed advisable to represent this quantity by diagram as well as by figures. In each of the 46 experiments conducted on fields there is inserted a small illustration to the left of the statement. This is drawn on a scale of one

inch to the foot and shows graphically the quantity of water applied in irrigation as well as the rainfall. The dark portion represents the amount received in irrigation, the light portion, the amount received in rainfall.

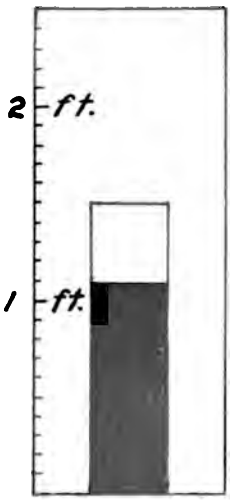
In experiment No. 1, for instance, the reader who glances at the diagram observes that more than two-thirds of the total amount of water received is from irrigation. If he wishes the exact figures, the statement shows that 1.02 feet, or 12¼ inches, was spread over the entire surface of a 31-acre clover field and that the amount of rain which fell on the same surface during the period of growth was .44 feet, or 5¼ inches.

The duty of water under the canals for 1902 is illustrated by the plates, which are modeled after those in Bulletin No. 86, U. S. Department of Agriculture. The dark portion of the main illustration shows when the water began to be used, the daily amount and the end of the irrigation season. The smaller cut to the right shows the duty of water for each month as well as the rainfall for the same period.



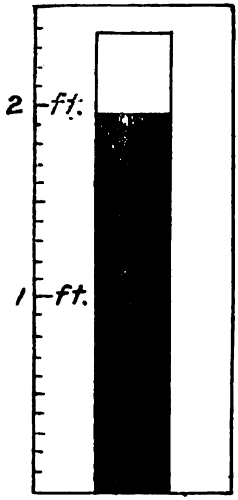
Experiment No. 1.

Location	Gallatin Valley.
Crop	Clover.
Yield per acre	3 tons.
Nature of soil.................	Clay loam.
Area	31 acres.
Date of first irrigation	June 17-22.
Date of second irrigation.......	July 26-Aug. 2.
Average head of water used....	1.54 cu. ft. per sec.
Depth of water applied........	1.02 ft.
Rainfall	.44 ft.
Total depth of water received..	1.46 ft.



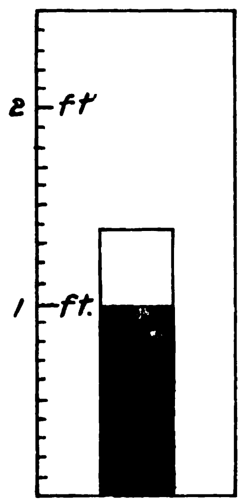
Experiment No. 2.

Location	Gallatin Valley.
Crop	Peas.
Yield per acre	31.25 bushels.
Nature of soil	Clay loam.
Area	4.23 acres.
Date of first irrigation.........	June 28.
Date of second irrigation.......	July 11-12.
Average head of water used....	1.28 cu. ft. per sec.
Depth of water applied	1.10 ft.
Rainfall	.41 ft.
Total depth of water received..	1.51 ft.



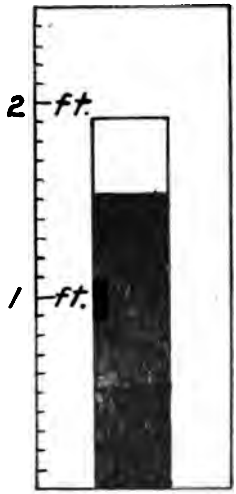
Experiment No. 3.

Location	Gallatin Valley.
Crop	Grain.
Yield per acre	57.89 bushels.
Nature of soil	Loam.
Area	11.27 acres.
Date of first irrigation	June 23-27.
Date of second irrigation	July 12-14.
Average head of water used	1.81 cu. ft. per sec.
Depth of water applied	1.98 ft.
Rainfall	0.42 ft.
Total depth of water received ..	2.40 ft.



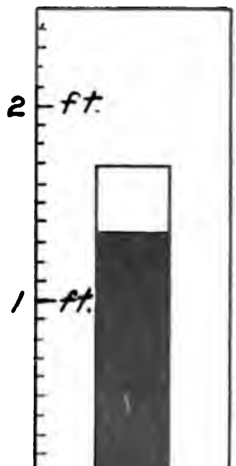
Experiment No. 4.

Location	Gallatin Valley.
Crop	Barley.
Yield per acre	73 bushels.
Nature of soil	Loam.
Area	66.39 acres.
Date of first irrigation	July 5-13.
Average head of water used	4.04 cu. ft. per sec.
Depth of water applied	0.98 ft.
Rainfall	0.41 ft.
Total depth of water received ..	1.39 ft.



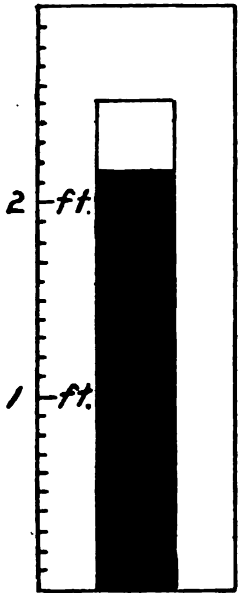
Experiment No. 5.

Location........................	Gallatin Valley.
Crop..........................	Oats.
Yield per acre.................	51 bushels.
Nature of Soil.................	Clay loam.
Area..........................	23.41 acres.
Date of first irrigation.........	July 13–18
Average feed of water used.....	3.54 cu. ft. per sec.
Depth of water applied........	1.53 ft.
Rainfall......................	.38 ft.
Total depth of water received..	1.91 ft.



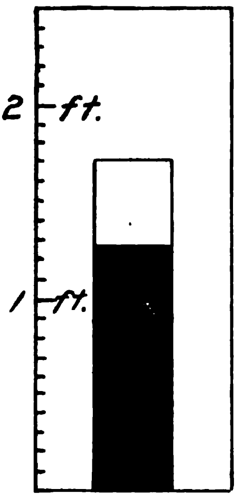
Experiment No. 6.

Location........................	Gallatin Valley.
Crop..........................	Oats.
Yield per acre.................	72.75 bushels.
Nature of Soil.................	Clay loam.
Area..........................	7.26 acres.
Date of first irrigation.........	July 6–7.
Date of second irrigation......	July 22–24.
Average head of water used....	1.58 cu. ft. per sec.
Depth of water applied.........	1.34 ft.
Rainfall......................	.36 ft.
Total depth of water received..	1.70 ft.



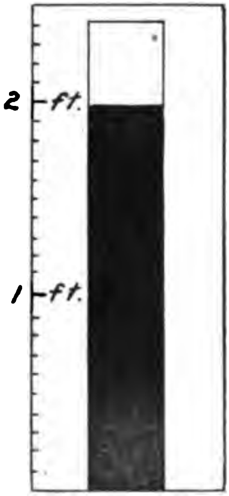
Experiment No. 7.

Location	Gallatin Valley.
Crop	Oats.
Yield per acre	72.75 bushels.
Nature of soil.................	Clay loam.
Area	2.48 acres.
Date of first irrigation	July 7-8.
Date of second irrigation	July 25.
Average head of water used....	1.96 cu. ft. per sec.
Depth of water applied	2.16 ft.
Rainfall	.36 ft.
Total depth of water received..	2.52 ft.



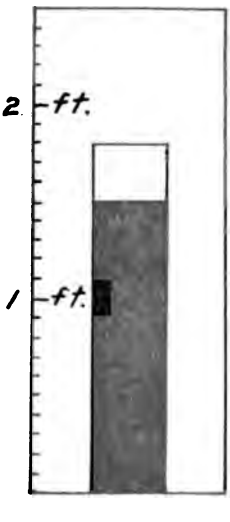
Experiment No. 8.

Location	Gallatin Valley.
Crop	Oats.
Nature of soil..................	Dark loam.
Area	25.09 acres
Date of first irrigation	July 20-26.
Average head of water used....	3.13 cu. ft. per sec.
Depth of water applied	1.28 ft.
Rainfall	.44 ft.
Total depth of water received..	1.72 ft.



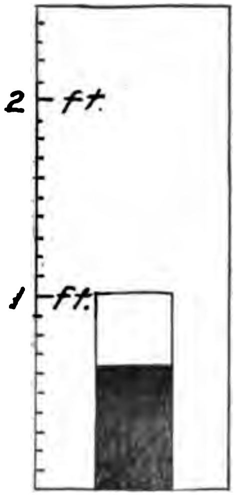
Experiment No. 9.

Location	Gallatin Valley.
Crop	Clover.
Nature of soil..................	Clay loam.
Area	66.39 acres.
Date of first irrigation	June 14-22.
Date of second irrigation.......	July 28-Aug. 17.
Average head of water used....	2.54 cu. ft. per sec.
Depth of water applied	1.98 ft.
Rainfall	.44 ft.
Total depth of water received..	2.42 ft.



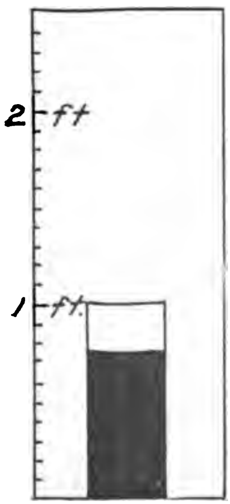
Experiment No. 10.

Location	Gallatin Valley.
Crop	Barley.
Yield per acre	46.5 bushels.
Nature of soil..................	Dark loam.
Area	4.14 acres.
Date of first irrigation	June 12-13.
Date of second irrigation.......	June 29-July 1.
Average head of water used....	1.24 cu. ft. per sec.
Depth of water applied	1.50 ft.
Rainfall	.28 ft.
Total depth of water received ..	1.78 ft.



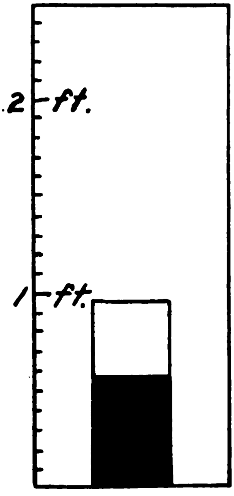
Experiment No. 11.

Location	Gallatin Valley.
Crop	Oats.
Nature of soil	Clay loam.
Area	25.09 acres.
Date of first irrigation	June 18–21.
Date of second irrigation	July 23–29.
Average head of water used	1.40 cu. ft. per sec.
Depth of water applied	.64 ft.
Rainfall	.39 ft.
Total depth of water received	1.03 ft.



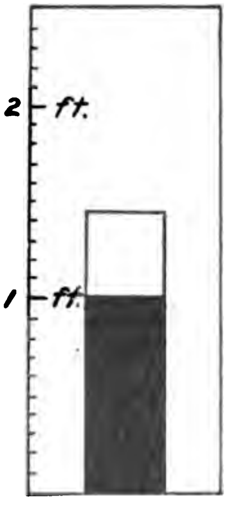
Experiment No. 12.

Location	Gallatin Valley.
Crop	Wheat and Clover.
Yield per acre	38.33 bu.3,170 lb.clover
Nature of soil	Garden loam.
Area	2 acres.
Date of first irrigation	June 18.
Date of second irrigation	July 11-12.
Average head of water used	1.40 cu. ft. per sec.
Depth of water applied	.77 ft.
Rainfall	.30 ft.
Total depth of water received	1.07 ft.



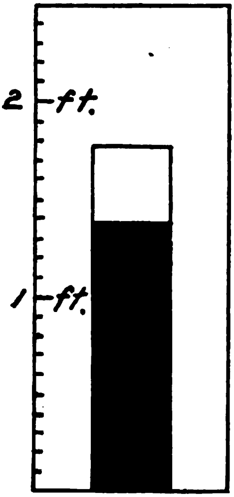
Experiment No. 13.

Location	Gallatin Valley.
Crop	Oats and Peas.
Yield per acre	75.58 bu. O. 1330 lb. P
Nature of soil	Loam.
Area	2 acres.
Date of first irrigation	June 18.
Date of second irrigation	July 11.
Average head of water used	1.37 cu. ft. per sec.
Depth of water applied	.56 ft.
Rainfall	.39 ft.
Total depth of water received	.95 ft.



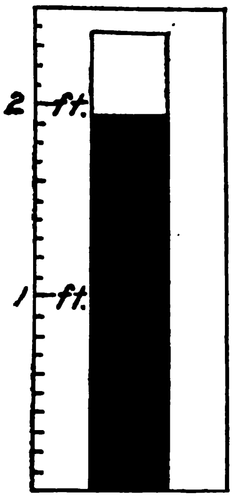
Experiment No. 14.

Location	Gallatin Valley.
Crop	Barley.
Yield per acre	87.29 bushels.
Nature of soil	Loam.
Area	1 acre.
Date of first irrigation	June 19.
Date of second irrigation	July 12.
Average head of water used	1.38 cu. ft. per sec.
Depth of water applied	1.17 ft.
Rainfall	.28 ft.
Total depth of water received	1.45 ft.



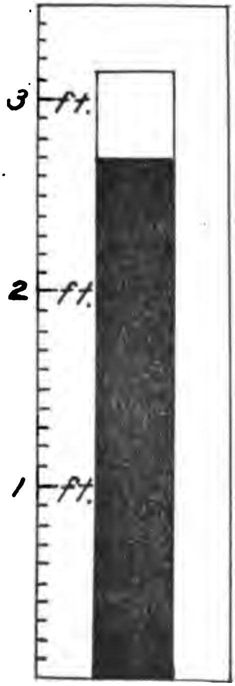
Experiment No. 15.

Location	Gallatin Valley.
Crop	Oats.
Yield per acre	74.67 bushels.
Nature of soil	Loam.
Area	8.51 acres.
Date of first irrigation	June 15-17.
Date of second irrigation	July 6-7.
Average head of water use	1.86 cu. ft. per sec.
Depth of water applied	1.39 ft.
Rainfall	0.40 ft.
Total depth of water received	1.79 ft.



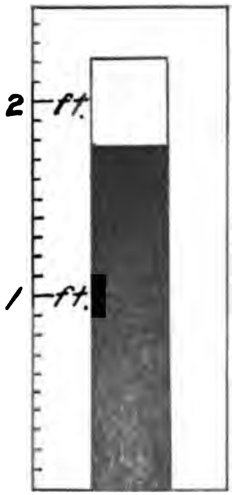
Experiment No. 16.

Location	Gallatin Valley.
Crop	Barley.
Yield per acre	68.59 bushels.
Nature of soil	Loam.
Area	4.52 acres.
Date of first irrigation	June 13 14.
Date of second irrigation	July 1-2.
Average head of water used	1.99 cu. ft. per sec.
Depth of water applied	1.96 ft.
Rainfall	0.42 ft.
Total depth of water received	2.38 ft.



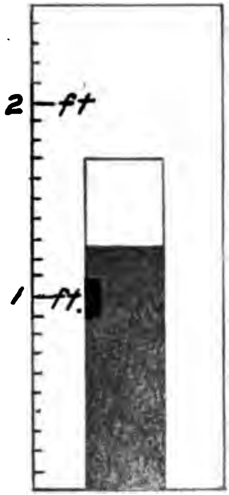
Experiment No. 17.

Location	Gallatin Valley.
Crop	Clover.
Yield per acre	5 tons.
Nature of soil	Clay loam.
Area	7.26 acres.
Date of first irrigation	June 4-5.
Date of second irrigation	July 3-5.
Date of third irrigation	July 19-21.
Date of fourth irrigation	Aug. 1-4.
Average head of water used	1.57 cu. ft. per sec.
Depth of water applied	2.70 ft.
Rainfall	.44 ft.
Total depth of water received ..	3.14 ft.



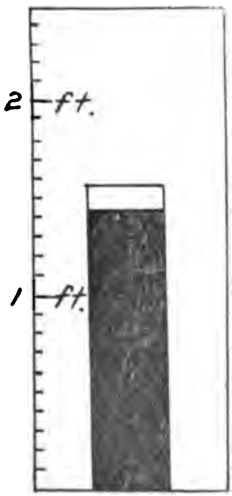
Experiment No. 18.

Location	Gallatin Valley.
Crop	Clover.
Nature of soil	Clay loam.
Area	35.9 acres.
Date of first irrigation	June 5-7.
Date of second irrigation	July 13-16.
Date of third irrigation	July 26-28.
Average head of water used	2.22 cu. ft. per sec.
Depth of water applied	1.79 ft.
Rainfall	.44 ft.
Total depth of water received ..	2.23 ft.



Experiment No. 19.

Location	Yellowstone County.
Crop	Alfalfa.
Yield per acre................	5.17 tons.
Nature of soil..................	Clay loam.
Area irrigated	53.4 acres.
Date of first irrigation.........	July 17-27.
Average head of water used....	3.52 cu. ft. per sec.
Depth of water applied	1.30 ft.
Rainfall	.44 ft.
Total depth of water received..	1.74 ft.

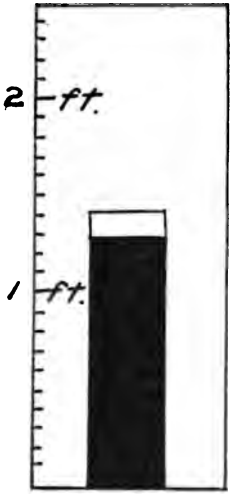


Experiment No. 20.

Location	Bitter Root Valley.
Crop	Orchard.
Nature of soil..................	Vegetable loam.
Area	40 acres.
Date of first irrigation.........	April 28-30.
Date of second irrigation.......	June 7-13.
Date of third irrigation........	July 9-14.
Date of fourth irrigation.......	Aug. 12-14.
Average head of water used....	2.36 cu. ft. per sec.
Depth of water applied	1.46 ft.
Rainfall	.13 ft.
Total depth of water received..	1.59 ft.

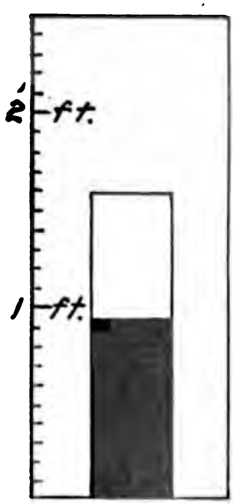
Experiment No. 21.

Location	Bitter Root Valley.
Crop	Oats.
Yield per acre	34.03 bushels.
Nature of soil	Gravelly.
Area	102.2 acres.
Date of first irrigation	May 23-June 19.
Date of second irrigation	July 19-Aug. 8
Average head of water used	7.05 cu. ft. per sec.
Depth of water applied	6.06 ft.
Rainfall	.13 ft.
Total depth of water received	6.19 ft.



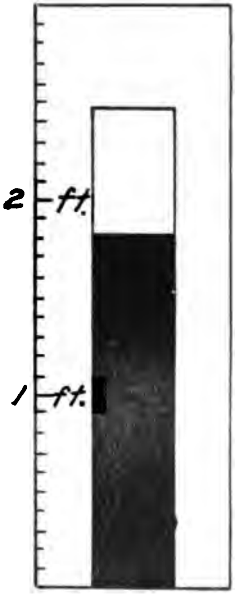
Experiment No. 22.

Location	Bitter Root Valley.
Crop	Oats.
Yield per acre	33.37 bushels.
Nature of soil	Vegetable Loam.
Area	161.7 acres.
Date of first irrigation	May 22, June 11.
Date of Second irrigation	July 21-30.
Average head of water used	3.75 cu. ft. per sec.
Depth of water applied	1.30 ft.
Rainfall	.13 ft.
Total depth of water received ..	1.43 ft.



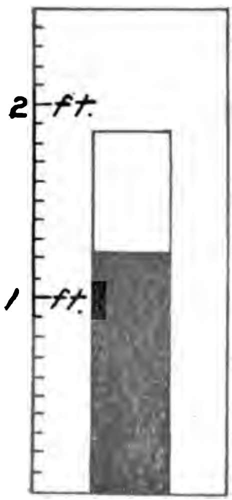
Experiment No. 23.

Location	Gallatin Valley.
Crop	Clover.
Yield per acre	3.36 tons.
Nature of soil	Loam.
Area	20.86 acres.
Date of first irrigation	June 5-7.
Date of second Irrigation	July 20-22, Aug. 2-7,
Date of second irrigation	Aug. 11-16.
Average head of water used	1.52 cu. ft. per sec.
Depth of water applied	.92 ft.
Rainfall	.65 ft.
Total depth of water received ..	1.57 ft.



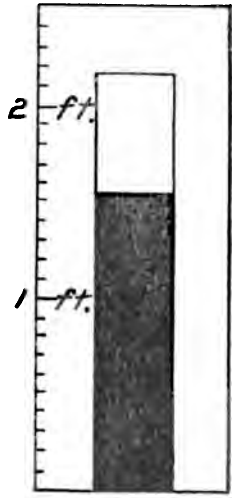
Experiment No. 24.

Location	Gallatin Valley.
Crop	Clover.
Yield per acre	3.36 tons.
Nature of soil	Clay loam.
Area	5.58 acres
Date of first irrigation	June 8,
Date of second irrigation	July 9-10
Date of third irrigation	July 25-29
Average head of water used	1.38 cu. ft. per sec.
Depth of water applied	1.81 ft.
Rainfall	.67 ft.
Total depth of water received	2.48 ft.



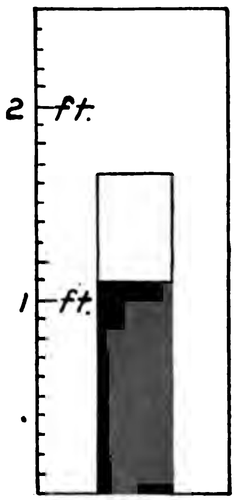
Experiment No. 25.

Location	Gallatin Valley.
Crop	Clover.
Nature of soil	Clay loam.
Area	7.13 acres.
Date of first irrigation	June 17-18.
Date of second irrigation	July 14-15.
Average head of water used	1.65 cu. ft. per sec.
Depth of water applied	1.24 ft.
Rainfall	.62 ft.
Total depth of water received	1.86 ft.



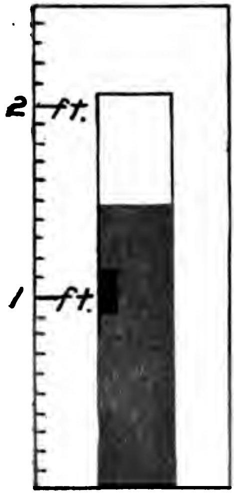
Experiment No. 26.

Location	Gallatin Valley.
Crop	Clover.
Nature of soil	Loam.
Area	6.85 acres.
Date of first irrigation	June 18-19.
Date of second irrigation	July 12-13.
Date of third irrigation	July 29-Aug. 6.
Average head of water used	1.40 cu. ft. per sec.
Depth of water applied	1.54 ft.
Rainfall	.62 ft.
Total depth of water received	2.16 ft.



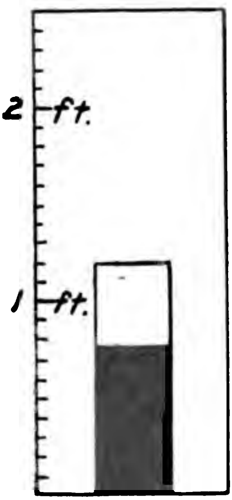
Experiment No. 27.

Location	Gallatin Valley.
Crop	Wheat.
Yield per acre	43.2 bushels.
Nature of soil	Loam.
Area	5.24 acres.
Date of first irrigation	June 27-28.
Date of second irrigation	July 13-14.
Average head of water used	1.47 cu. ft. per sec.
Depth of water applied	1.19 ft.
Rainfall	.45 ft.
Total depth of water received	1.64 ft.



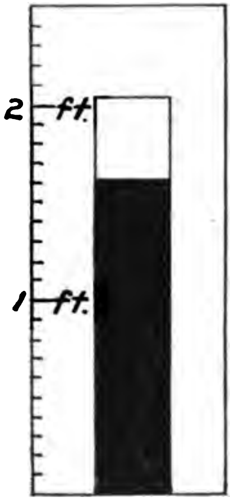
Experiment No. 28.

Location........................	Gallatin Valley.
Crop...........................	Wheat, Barley, Clover.
Yield per acre..................	42.9bu 61.5bu 1.59 tons
Nature of soil.................	Clay loam.
Area	3 acres
Date of first irrigation.........	June 28-29
Date of second irrigation......	July 15-16
Average head of water used....	1.23 cu. ft. per sec.
Depth of water applied........	.76 ft.
Rainfall........................	.43 ft.
Total depth of water received..	1.19 ft.



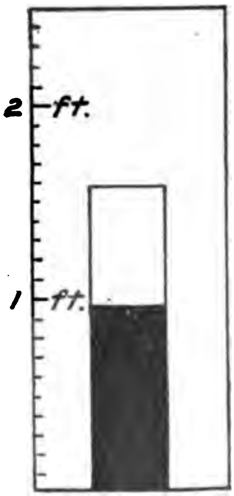
Experiment No. 29.

Location	Gallatin Valley.
Crop...........................	Sugar Beets.
Yield per acre.................	10 ton,
Nature of soil..................	Clay loam.
Area	3 acres.
Date of first irrigation.........	July 13-14.
Date of second irrigation......	July 29-30.
Date of third irrigation........	Aug. 16-17.
Average head of water used..	.44 cu. ft. per sec.
Depth of water applied	1.46 ft.
Rainfall.......................	.59 ft.
Total depth of water received..	2.05 ft.



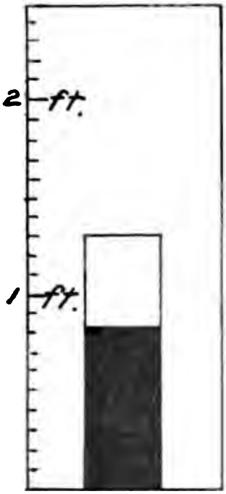
Experiment No, 30.

Location	Gallatin Valley
Crop..........................	Oats
Yield per acre.................	73 bushels.
Nature of soil.................	Clay loam
Area	15.35 acres
Date of first irrigation.........	June 28–July 2
Date of second irrigation......	July 16–17, July 22-25
Average head of water used....	1.63 cu. ft. per sec.
Depth of water applied........	1.62 ft.
Rainfall.......................	.43 ft.
Total depth of water received..	2.05 ft.



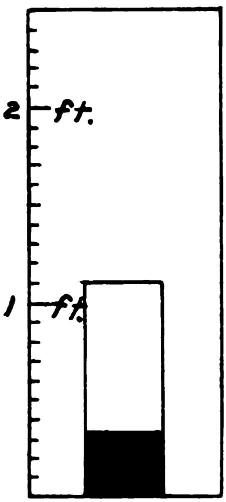
Experiment No. 31,

Location	Gallatin Valley
Crop..........................	Clover.
Nature of soil................	Clay loam.
Area	27.84 acres
Date of first irrigation.........	June 21-25
Average head of water used..	3.33 cu. ft. per sec.
Depth of water applied........	.95 ft.
Rainfall.......................	.62 ft.
Total depth of water received..	1.57 ft.



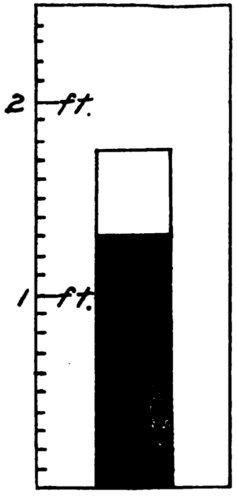
Experiment No. 32.

Location	Gallatin Valley.
Crop	Barley.
Yield per acre	59 bushels.
Nature of soil.................	Loam.
Area	12.5 acres.
Date of first irrigation	July 2-3, July 5-6.
Average head of water used....	2.18 cu. ft. per sec.
Depth of water applied	.34 ft.
Rainfall	.46 ft.
Total depth of water received..	1.30 ft.



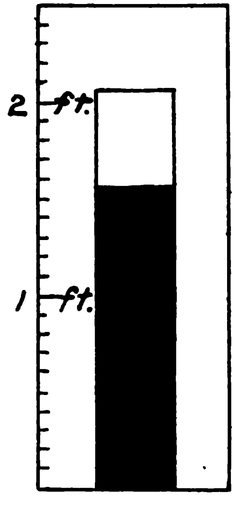
Experiment No. 33.

Location	Gallatin Valley.
Crop	Peas.
Yield per acre	37.5 bushels.
Nature of soil.................	Clay loam.
Area	8.40 acres.
Date of first irrigation	July 8-9.
Average head of water used....	1.67 cu. ft. per sec.
Depth of water applied	.35 ft.
Rainfall	.77 ft.
Total depth of water received..	1.12 ft.



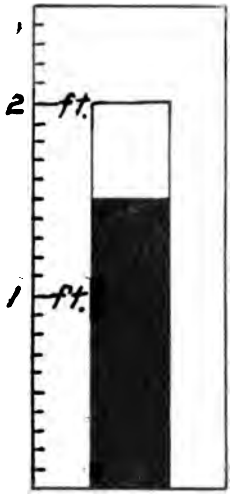
Experiment No, 34.

Location	Gallatin Valley
Crop	Oats
Nature of soil	Loam
Area	37.3 acres
Date of first irrigation	July 9-23
Average head of water used	1.66 cu. ft. per sec.
Depth of water applied	1.26 ft.
Rainfall	.45 ft.
Total depth of water received	1.71 ft.



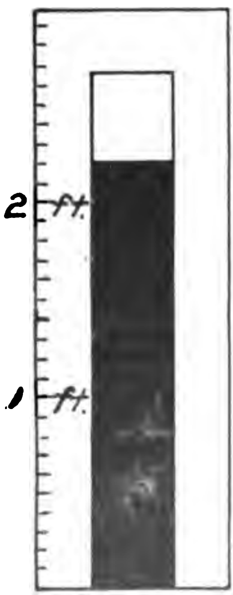
Experiment No. 35,

Location	Gallatin Valley
Crop	Orchard.
Nature of soil	Gravelly loam.
Area	40 acres
Date of first irrigation	April 15-18
Date of second irrigation	June 27-30
Date of third irrigation	Aug. 13-18
Date of fourth irrigation	Sept. 1-2
Average head of water used	2.43 cu. ft. per sec.
Depth of water applied	1.56 ft.
Rainfall	.49 ft.
Total depth of water received	2.05 ft.



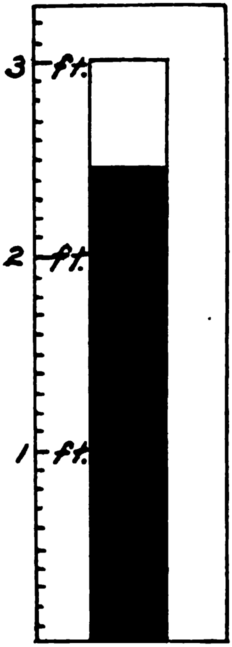
Experiment No. 36.

Location	Bitter Root Valley.
Crop	Clover.
Yield per acre	1.06 tons.
Nature of soil	Gravelly loam.
Area irrigated	161.7 acres.
Date of first irrigation	May 11-28.
Date of second irrigation	June 23–July 2.
Date of third irrigation	Aug. 29–Sept. 8.
Average head of water used	3.40 cu. ft. per sec.
Depth of water applied	1.50 ft.
Rainfall	.49 ft.
Total depth of water received	1.99 ft.



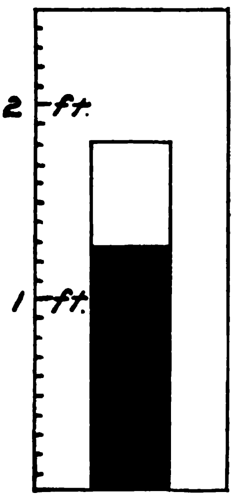
Experiment No. 37.

Location	Bitter Root Valley.
Crop	Clover.
Yield per acre	1 ton.
Nature of soil	Gravelly.
Area	102. acres.
Date of first irrigation	Apr. 20–May 2
Date of second irrigation	May 4–16, 21–30.
Date of third irrigation	June 11–July 3.
Date of fourth irrigation	July 29–Aug. 13
Average head of water used	4.01 cu. ft. per sec.
Depth of water applied	2.22 ft.
Rainfall	.45 ft.
Total depth of water received	2.67 ft.



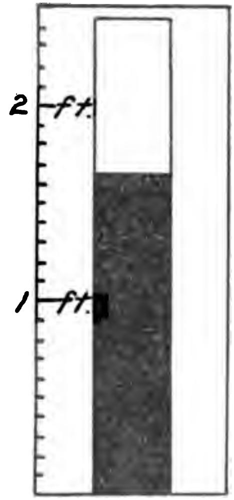
Experiment No. 38.

Location	Gallatin Valley.
Crop	Oats.
Nature of soil	Clay loam.
Area	5.38 acres.
Date of first irrigation	June 24-26.
Date of second irrigation	July 17-18.
Average head of water used	1.30 cu. ft. per sec.
Depth of water applied	1.27 ft.
Rainfall	.54 ft.
Total depth of water received	1.81 ft.



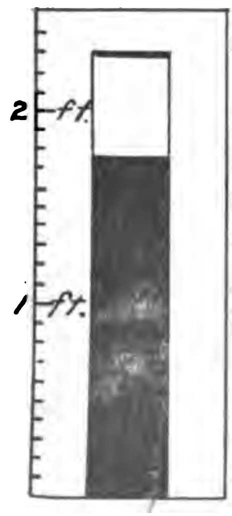
Experiment No. 39.

Location	Gallatin Valley.
Crop	Wheat.
Nature of soil	Clay loam.
Area	5.62 acres.
Date of first irrigation	June 22-23.
Date of second irrigation	July 25-31.
Average head of water used	2.43 cu. ft. per sec.
Depth of water applied	2.43 ft.
Rainfall	.72 ft.
Total depth of water received	3.15 ft.



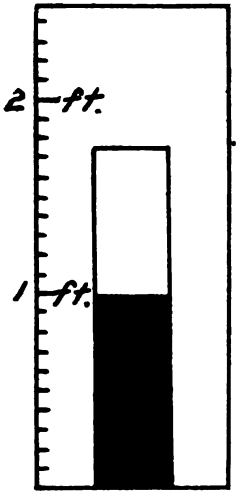
Experiment No. 40.

Location	Gallatin Valley.
Crop	Clover.
Nature of soil..................	Clay loam.
Area	9.72 acres.
Date of first irrigation........	June 3-6.
Date of second irrigation.......	July 13-17.
Average head of water used....	1.79 cu. ft. per sec.
Depth of water applied	1.65 ft.
Rainfall	.78 ft.
Total depth of water received..	2.43 ft.



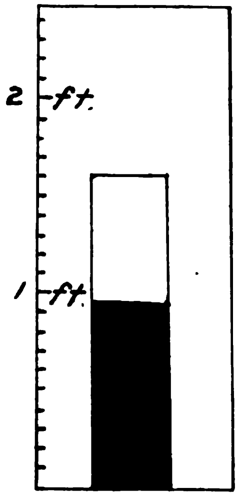
Experiment No. 41.

Location	Gallatin Valley.
Crop	Oats.
Nature of soil..................	Clay loam.
Area	8.93 acres.
Date of first irrigation.........	June 11-14.
Date of second irrigation.......	July 19-22.
Average head of water used....	1.49 cu. ft. per sec.
Depth of water applied	1.76 ft.
Rainfall	.54 ft.
Total depth of water received..	2.30 ft.



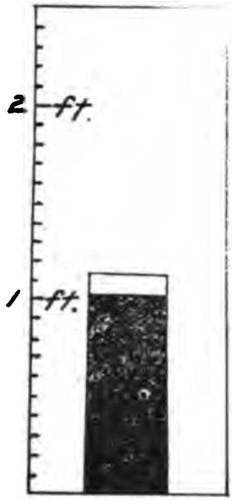
Experiment No. 42.

Location	Gallatin Valley.
Crop	Alfalfa.
Nature of soil	Clay loam.
Area	4.02 acres.
Date of first irrigation	June 10-11.
Date of second irrigation	July 17-18.
Average head of water used	1.56 cu. ft. per sec.
Depth of water applied	1.01 ft.
Rainfall	.78 ft.
Total depth of water received	1.79 ft.



Experiment No. 43.

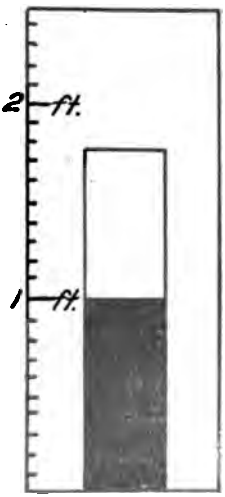
Location	Gallatin Valley.
Crop	Barley.
Nature of soil	Clay loam.
Area	19.8 acres
Date of first irrigation	June 14-17.
Date of second irrigation	July 25-30.
Average head of water used	2.17 cu. ft. per sec.
Depth of water applied	.97 ft.
Rainfall	.64 ft.
Total depth of water received	1.61 ft.



Experiment No. 44.

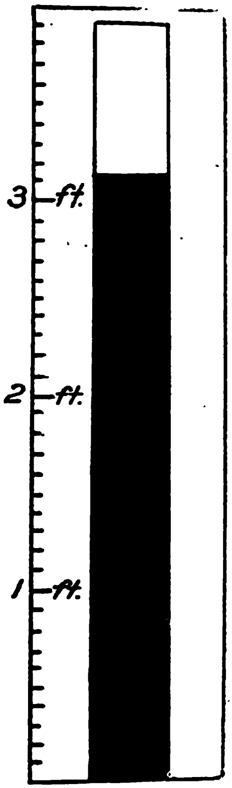
Location	Gallatin Valley.
Crop	Rotation Plats.
Nature of soil	Clay loam.
Area	6 acres.
Date of first irrigation	June 26-27.
Date of second irrigation	July 18-19.
Average head of water used	1.92 cu. ft. per sec
Depth of water applied	1.07 ft.
Rainfall	.64 ft.
Total depth of water received	1.71 ft.

NOTE: Rainfall as given in cut is incorrect and should be .64 ft.



Experiment No. 45.

Location	Gallatin Valley.
Crop	Clover.
Nature of soil	Loam.
Area	27.84 acres.
Date of first irrigation	June 17-24.
Depth of water applied	1.00 ft.
Rainfall	.78 ft.
Total depth of water received	1.78 ft.



Experiment No. 46.

Location	Gallatin Valley.
Crop	Clover.
Nature of soil	Loam.
Area	81.3 acres
Date of first irrigation	June 6–30
Average head of water used	0.83 cu. ft. per sec.
Depth of water applied	3.13 ft.
Rainfall	.78 ft.
Total depth of water received	3.91 ft.

Table No. 1.

In the following table, the length of the irrigation season for each of the valleys in which experiments were made has been fixed. Knowing approximately the number of days in which water is used, it is possible to determine the duty of water in acres per cubic foot per second and also per miner's inch. This has been done in columns 8 and 9 of table.

1899.

KIND OF CROP.	COUNTY.	AREA IRRIGATED IN ACRES.	YIELD PER ACRE	LENGTH OF IRRIGATION SEASON.	RAINFALL IN DEPTH OVER SURFACE.	AMOUNT OF WATER APPLIED.		
						IN DEPTH OVER SURFACE.	IN ACRES PER CU. FT. PER SEC.	IN ACRES PER MINER'S, INCH.
				June 1-Aug. 31	FEET.	FEET.		
Clover.....	Gallatin.	27.44	3 tons.	92 Days	.44	1.02	179	4.4
Peas.......	"	4.23	31.25 bu.	"	.41	1.10	166	4.1
Grain......	"	11.27	51.46 "	"	.42	1.98	92	2.3
Barley.....	"	66.39		"	.41	.98	186	4.6
Oats.......	"	23.41	51.00 bu.	"	.38	1.53	119	3.0
Oats.......	"	7.26	72.75 bu.	"	.36	1.34	136	3.4
Oats.......	"	2.48	72.75 bu.	"	.36	2.16	84	2.1
Oats.......	"	25.00		"	.44	1.28	143	3.6

1900.

KIND OF CROP.	COUNTY.	AREA IRRIGATED IN ACRES.	YIELD PER ACRE	LENGTH OF IRRIGATION SEASON.	RAINFALL IN DEPTH OVER SURFACE.	AMOUNT OF WATER APPLIED.		
						IN DEPTH OVER SURFACE.	IN ACRES PER CU. FT. PER SEC.	IN ACRES PER MINER'S INCH.
				June 1-Aug 31.	FEET	FEET		
Clover.....	Gallatin.	66.39		92 days	.44	1.98	92	2.3
Barley.....	"	4.14	46.50 bu.	"	.28	1.50	122	3.1
Oats.......	"	25.09		"	.39	.64	285	7.1
Wheat 1 a.			w-38.33 bu	"				
Clover 1 a.	"	2.00	c-3170 lb.	"	.30	.77	237	5.6
Oats 1 a...			o-75.58bu.	"				
Peas 1 a...	"	2.00	p-1330 lb.	"	.39	.56	326	8.2
Barley.....	"	1.00	87.29 bu.	"	.28	1.17	156	3.9
Oats.......	"	8.51	74.67 "	"	.40	1.39	131	3.3
Barley.....	"	4.52	68.59 "	"	.42	1.96	93	2.3
Clover.....	"	7.26	5.00 tons.	May 18-Sept. 30	.44	2.70	67	1.7
Clover.....	"	35.90		135 days	.44	1.79	102	2.5
Alfalfa....	Yellowstone.	53.40	5.17 tons.	Apr. 25-Aug. 31	.44	1.30	206	5.1
Orchard...	Ravalli.	40.00		128 days	.13	1.46	174	4.3
Oats.......	"	161.70	33.00 bu.	"	.13	1.30	195	4.9
Oats.......	"	102.20	34.00 bu.	"	.13	6.06	42	1.0

1901

KIND OF CROP.	COUNTY.	AREA IRRIGATED IN ACRES.	YIELD PER ACRE	LENGTH OF IRRIGATION SEASON.	RAINFALL IN DEPTH OVER SURFACE.	AMOUNT OF WATER APPLIED.		
						IN DEPTH OVER SURFACE.	IN ACRES PER CU. FT. PER SEC.	IN ACRES PER MINER'S INCH.
					FEET	FEET		
Clover.....	Gallatin.	20.86	3.36 tons	June 1-Aug. 31, 92 days.	.65	.92	193	4.9
Clover.....	"	5.59	3.36 "		.67	1.81	101	2,5
Clover.....	"	7.13	3.36 "	"	.62	1.24	147	3.7
Clover.....	"	6.85	3.36 "	"	.62	1.55	118	2.9
Wheat	"	5.25	46.20 bu.	"	.45	1.20	152	3.8
Wheat 1 a.	"	1.00	w-42.90 "	"	.34	0.77	237	5.9
Barley 1 a.	"	1.00	B-61.50 "	"	.43	0.77	237	5.9
Clover 1 a.	"	1.00	C-1.59 ton	"	.43	0.77	237	5.9
Sugar beet	"	1.00	10 tons	"	.59	1.46	125	3.1
Oats.......	"	15.33	73 bu.	"	.43	1.63	112	2.3
Clover.....	"	27.84	3 tons	"	.62	.95	192	4.8
Barley.....	"	12.47	59.0 bu.	"	.46	.85	215	5.4
Peas.......	"	8.41	37.5 bu.	"	.77	.35	321	13.0
Oats.......	"	37.30		Apr25-Aug. 31, 128 days.	.45	1.27	144	3.6
Orchard...	Ravalli.	40.00			.49	1.56	163	4.1
Clover.....	"	161.70	0.9 ton	"	.49	1.50	169	4.2
Clover.....	"	102.00	1.0 ton	"	.45	2.22	114	2.8

1902

KIND OF CROP.	COUNTY.	AREA IRRIGATED IN ACRES.	YIELD PER ACRE	LENGTH OF IRRIGATION SEASON.	RAINFALL IN DEPTH OVER SURFACE.	AMOUNT OF WATER APPLIED.		
						IN DEPTH OVER SURFACE.	IN ACRES PER CU. FT. PER SEC.	IN ACRES PER MINER'S INCH.
					FEET	FEET		
Barley	Gallatin.	19.80		June 1-Aug. 31 92 days	.64	.97	189	4.7
Rotation Plats	"	6.00		"	.64	1.07	171	4.3
Wheat.....	"	5.61		"	.72	2.44	75	1.9
Oats.......	"	3.38		"	.54	1.27	144	3.6
Clover.....	"	9.72		"	.78	1.66	110	2.7
Oats.......	"	8.93		"	.54	1.77	103	2.6
Alfalfa	"	4.02		"	.78	1.01	181	4.5
Clover.....	"	27.84		"	.78	1.78	103	2.6
Clover.....	"	81.30		"	.78	3.13	58	1.5

DUTY OF WATER UNDER CANALS.

As has already been stated, the amount of water used under canals is much greater than under laterals, or on individual farms or fields. This difference is readily accounted for when one takes into consideration the porous character of most channels, the defects in construction and the loss due to evaporation. In addition to this, there is another loss. Except during the busy part of the irrigation season, most canals carry a surplus which is allowed to flow through, or over, waste-gates and return to the natural stream. The stockholder of a canal company prefers to waste a part of his allowance rather than wait until an additional supply can be turned in at the headgate miles away from his farm. Hence it follows that during the first and last part of the irrigation season, or during a rainy spell, considerably more water is allowed to flow through the canal than is utilized. In determining the duty of water under canals it was not practicable to measure losses of this nature. Each canal was measured daily at some suitable point near the head and the flow expressed in acre-feet. It will be remembered that an acre-foot is the quantity of water which will cover an acre one foot deep. When the flow of a canal is given in acre-feet it can be readily changed into miners' inches by multiplying the former by 20. This method is not quite exact but will answer for all practical purposes. In one of the accompanying tables the flow of the Big Ditch in Yellowstone county on July 22, 1902, is given as 710 8-10 acre-feet. Multiplying 710 8-10 by 20 gives 14216 miners' inches. The exact number is 14,336 miners' inches.

DUTY OF WATER UNDER THE BIG DITCH, YELLOWSTONE COUNTY

The canal now known as The Big Ditch is one of the largest in the state. It was begun in 1882 by the Minnesota and Montana Land and Improvement Company and completed several years later at a total cost of $110,000. The canal, as originally built, was to be 30 feet on the bottom over the upper portion, with side slopes of 1 to 1, a water depth of 3 feet and grade of 2½ feet per mile.

The headgates and diversion dam of this canal are located on a branch of Yellowstone river, below the Rapids and about 11 miles above Park City. The lower terminus is near the city of Billings, 39 miles distant. There are no diversions on the upper portion of the canal and the upper rating flume was in consequence located at Tilden's ranch, about five miles below the head. The daily discharge of the canal at this point has been determined for the past three seasons. The following table represents the total volumes passing this point expressed in acre-feet for the year named, the respective areas under irrigation, the depth of water applied and the duty of water in acres per miner's inch:

YEAR	ACRE-FEET.	ACRES.	DEPFH IN FEET.	ACRES PER MINER'S INCH.
1900	46.995			
1901	46,507	18,144	2.56	2.13
1902	73,165	20,038	3.65	1.90

The total volumes carried in 1900 and 1901 are about equal. The canal was enlarged before the beginning of the past season (1902) and as is shown by the foregoing table the volume was much increased. Part of this supply was wasted. Notwithstanding the quantities of water wasted the average duty of water over about 20,000 acres in Yellowstone county for the years 1901 and 1902 was at the rate of one-half a miner's inch per acre.

In order to familiarize the irrigators with the various units used in irrigation the daily discharge of The Big Ditch for 1901 and 1902 is given in the following tables in three ways, viz: in cubic feet per second, Montona miners' inches and in acre-feet:

TABLE SHOWING DISCHARGE OF THE BIG DITCH AT TILDEN'S RANCH, YELLOWSTONE COUNTY, MONTANA, FOR THE SEASON OF 1901,

	May.			June.			July.			August.		
	Cu. ft. per sec.	Miner's inches	Acre feet	Cu. ft. per sec.	Miner's inches	Acre feet	Cu. ft. per sec.	Miner's inches	Acre feet	Cu. ft. per sec.	Miner's inches	Acre feet
1	....	....	.....	174	6960	345.1	267	10680	529.5	246	9840	487.9
2	....	....	.....	174	6960	345.1	256	10240	507.7	246	9840	487.9
3	....	....	.....	174	6960	345.1	225	9000	446.2	246	9840	487.9
4	....	....	.....	174	6960	345.1	252	10080	499.8	246	9840	487.9
5	....	....	.....	174	6960	345.1	277	11080	549.3	236	9440	468.1
6	....	....	.....	174	6960	345.1	267	10680	529.5	236	9440	468.1
7	....	....	.....	174	6960	345.1	277	11080	549.3	236	9440	468.1
8	....	....	.....	174	6960	345.1	288	11520	571.2	225	9000	446.2
9	....	....	.....	174	6960	345.1	288	11520	571.2	225	9000	446.2
10	....	....	.....	174	6960	345.1	288	11520	571.2	225	9000	446.2
11	....	....	.....	174	6960	345.1	299	11960	593.0	225	9000	446.2
12	....	....	.....	174	6960	345.1	299	11960	593.0	215	8600	426.4
13	....	....	.....	184	7360	364.9	299	11960	593.0	215	8600	426.4
14	174	6960	345.1	184	7360	364.9	299	11960	593.0	257	10280	509.7
15	174	6960	345.1	164	6560	325.3	288	11520	571.2	257	10280	509.7
16	174	6960	345.1	164	6560	325.3	267	10680	529.5	246	9840	487.9
17	174	6960	345.1	164	6560	325.3	267	10680	529.5	246	9840	487.9
18	174	6960	345.1	164	6560	325.3	257	10280	509.7	246	9840	487.9
19	174	6960	345.1	143	5720	283.6	252	10080	499.8	236	9440	468.1
20	174	6960	345.1	143	5720	283.6	242	9680	480.0	236	9440	468.1
21	174	6960	345.1	143	5720	283.6	232	9280	460.1	236	9440	468.1
22	174	6960	345.1	112	4480	222.1	236	9440	468.1	236	9440	468.1
23	174	6960	345.1	112	4480	222.1	242	9680	480.0	267	10680	529.5
24	174	6960	345.1	112	4480	222.1	246	9840	487.9	257	10280	509.7
25	174	6960	345.1	91	3640	180.5	246	9840	487.9	236	9440	468.1
26	174	6960	345.1	91	3640	180.5	246	9840	487.9	236	9440	468.1
27	174	6960	345.1	225	9000	446.3	257	10280	509.7	194	7760	384.7
28	174	6960	345.1	225	9000	446.3	267	10680	529.5	184	7360	364.9
29	174	6960	345.1	246	9840	487.9	267	10680	529.5	174	6960	345.1
30	174	6990	345.1	277	11080	549.4	255	10200	505.7	164	6560	325.3
31	174	6960	345.1	...	.....	.....	242	9680	480.0	164	6560	325.3
	Totals....		6211.8			9980.5			16243.9			14070.6

Summary showing the amount of water applied to irrigated lands under The Big Ditch for the season of 1901:

Duration of irrigation season (May 14 to Aug. 31)........110 days.
Area irrigated.......................................18,144 acres.
Water diverted.......................................46,507 acre feet.
Average depth of water applied......................2.56 feet.

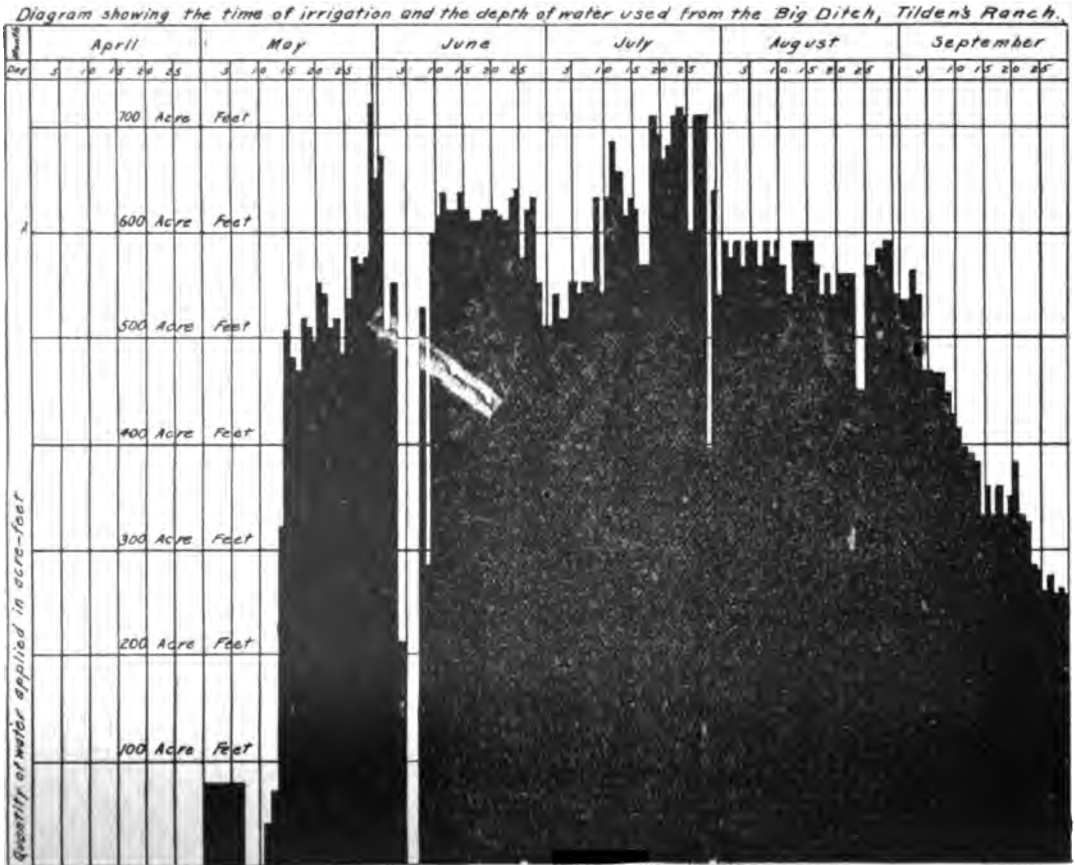


Diagram showing the time of irrigation and the depth of water used from the Big Ditch, Tilden's Ranch.
Month
Day
April
May
June
July
August
September
700 Acre Feet
600 Acre Feet
500 Acre Feet
400 Acre Feet
300 Acre Feet
200 Acre Feet
100 Acre Feet
Quantity of water applied in acre-feet

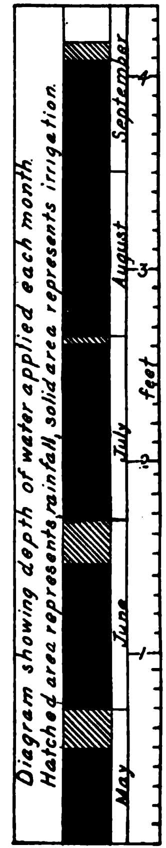


Diagram showing depth of water applied each month.
Hatched area represents rainfall, solid area represents irrigation.
May
June
July
August
September
feet

PLATE I

TABLE SHOWING DISCHARGE OF THE BIG DITCH AT TILDEN'S RANCH, YELLOWSTONE COUNTY, MONTANA, FOR THE SEASON OF 1902.

	May.			June.			July.			August.			September.		
	Cu.ft. per sec.	Miner's inches.	Acre feet.	Cu.ft. per sec.	Miner's inches.	Acre feet.	Cu.ft. per sec.	Miner's inches.	Acre feet.	Cu.ft. per sec.	Miner's inches.	Acre feet.	Cu.ft. per sec.	Miner's inches.	Acre feet.
1	.....	.....	......	338.1	13524	670.6	272.3	10892	540.1	293.9	11756	582.9	269.9	10796	535.3
2	.....	.....	......	254.4	10176	504.6	260.4	10416	516.5	290.3	11612	575.8	269.9	10796	535.3
3	.....	.....	......	278.3	11132	552.0	260.4	10416	516.5	293.9	11756	582.9	258.0	10320	511.7
4	.....	.....	......	104.9	4196	208.0	278.3	11132	552.0	286.7	11468	568.6	248.4	9938	492.7
5	.....	.....	......	.....	.....	......	284.3	11372	544.0	293.9	11756	582.9	236.4	9456	468.9
6	.....	.....	......	.....	.....	......	278.3	11182	552.0	293.9	11756	582.9	234.1	9364	464.3
7	.....	.....	......	.....	.....	......	278.3	11132	552.0	286.7	11468	568.6	234.1	9364	464.3
8	.....	.....	......	266.3	10652	528.2	266.3	10652	528.1	293.9	11756	582.9	226.9	9076	450.0
9	.....	.....	......	293.9	11756	582.9	284.3	11372	544.0	290.3	11652	575.8	222.1	8884	540.5
10	.....	.....	......	302.2	12088	599.4	320.2	12808	635.1	293.9	11756	582.9	214.9	8596	426.2
11	.....	.....	......	310.6	12424	616.0	346.5	13860	687.2	286.7	11468	568.6	210.1	8404	416.7
12	.....	.....	......	320.2	12808	635.1	332.1	13284	658.7	284.3	11322	544.0	200.6	8024	397.8
13	.....	.....	......	314.2	12568	623.2	310.6	12424	616.0	293.9	11756	582.9	197.6	7904	391.9
14	161.6	6464	320.5	314.2	12568	623.2	317.8	12712	630.3	293.9	11756	582.9	191.6	7664	380.0
15	254.4	10176	504.6	320.2	12808	635.1	314.2	12568	623.2	293.9	11756	582.9	167.7	6708	332.6
16	242.2	9696	480.8	314.2	12568	623.2	338.1	13524	670.6	293.9	11756	582.9	179.6	7184	356.2
17	235.0	9220	467.2	308.2	12328	611.3	338.1	13524	670.6	286.7	11468	568.6	167.7	6708	332.6
18	263.9	10556	523.4	308.2	12328	611.3	358.4	14336	710.8	272.3	10892	540.1	179.6	7184	356.2
19	255.6	10224	506.9	314.2	12568	623.2	350.1	14004	694.4	281.9	11276	559.1	167.7	6708	332.6
20	250.8	10032	497.4	314.2	12568	623.2	338.1	13524	670.6	272.3	10892	540.1	176.6	7064	350.2
21	278.3	11132	552.0	314.2	12568	623.2	344.1	13764	682.5	281.9	11296	559.1	191.6	7664	380.0
22	272.3	10892	540.1	310.6	12424	616.0	358.4	14336	710.8	281.9	11296	559.1	167.7	6708	332.6
23	255.6	10224	506.9	309.4	12376	613.6	362.0	14480	717.9	281.9	11296	559.1	164.7	6588	326.6
24	262.4	10496	520.4	317.8	12712	630.3	358.4	14336	710.8	226.9	9076	451.0	143.8	5752	285.2
25	244.8	9792	485.5	320.2	12808	635.1	353.6	14144	601.3	226.9	9076	451.0	140.8	5632	279.2
26	271.1	10844	537.7	290.3	11612	575.8	358.4	14336	710.8	286.7	11468	568.6	131.2	5248	260.2
27	290.3	11612	575.8	314.2	12568	623.2	358.4	14336	710.8	286.7	11468	568.6	137.8	5512	273.3
28	286.7	11468	568.6	317.8	12712	630.3	200.6	8024	397.8	293.9	11756	582.9	128.2	5128	254.2
29	290.3	11612	575.8	278.3	11132	552.0	326.1	13044	646.8	298.7	11948	592.4	131.2	5248	260.2
30	314.2	12568	723.2	256.8	10272	509.3	293.9	11756	582.9	298.7	11948	592.4	128.2	5123	254.2
31	328.5	13140	651.5	.....	.....	......	284.3	11372	544.0	274.7	10988	544.8	.....	.....	......
	Total.....		10197.7	....		15580.1	....		19134.5	....		17468.9	....		11442.9

Summary showing the amount of water applied to irrigated lands under The Big Ditch for the season of 1902:

Duration of irrigation season (May 14 to Sept. 30)....... 140 days.
Area irrigated...... .... 20,038 acres.
Water diverted.. 73,165 acre-feet.
Average depth of water applied...................... 3.65 feet.

Duty of Water in the Bitter Root Valley.

For three years investigations have been conducted in the Bitter Root Valley to determine the quantity of water used in irrigation and the various losses in its conveyance. The greater part of the work was performed on the Bitter Root stock farm, the property of the late Hon. Marcus Daly. The conditions on this farm are favorable for such investigations. Through the co-operation of the Superintendent, Mr. P. J. Shannon, and the irrigation engineer, Mr. M. D. Kippen, accurate data have been secured in regard to the area of land irrigated and the kinds of crops raised. The results obtained in 1900 were published in Bulletin No. 29 of this station. Bulletin No. 119 of the office of Experiment Stations contains the results of the investigations made in 1901 while the following tables give a summary of the data obtained in 1902.

DUTY OF WATER UNDER THE REPUBLICAN CANAL, RAVALLI COUNTY, MONTANA.

The costly headgates and diversion dam of the Republican Canal are located on the Bitter Root river near the junction of the tributary known as Sleeping Child. This canal for the first 5 miles has a bottom width of about 12 feet and an average depth of about 3 feet on a grade of 5 feet per mile. For the next 3 miles it has nearly the same slope as that of the river, or over 40 feet per mile. The canal decreases in width and volume as its distance from the head increases, and is quite narrow from the eight to the twentieth mile. The lower portion is located on a grade of eight feet per mile. In 1901 the flow of this canal varied from 2,000 to 3,200 miner's inches. In 1902 the highest flow was 3,927 miners' inches and the average for the season was nearly 2,200 miners' inches.

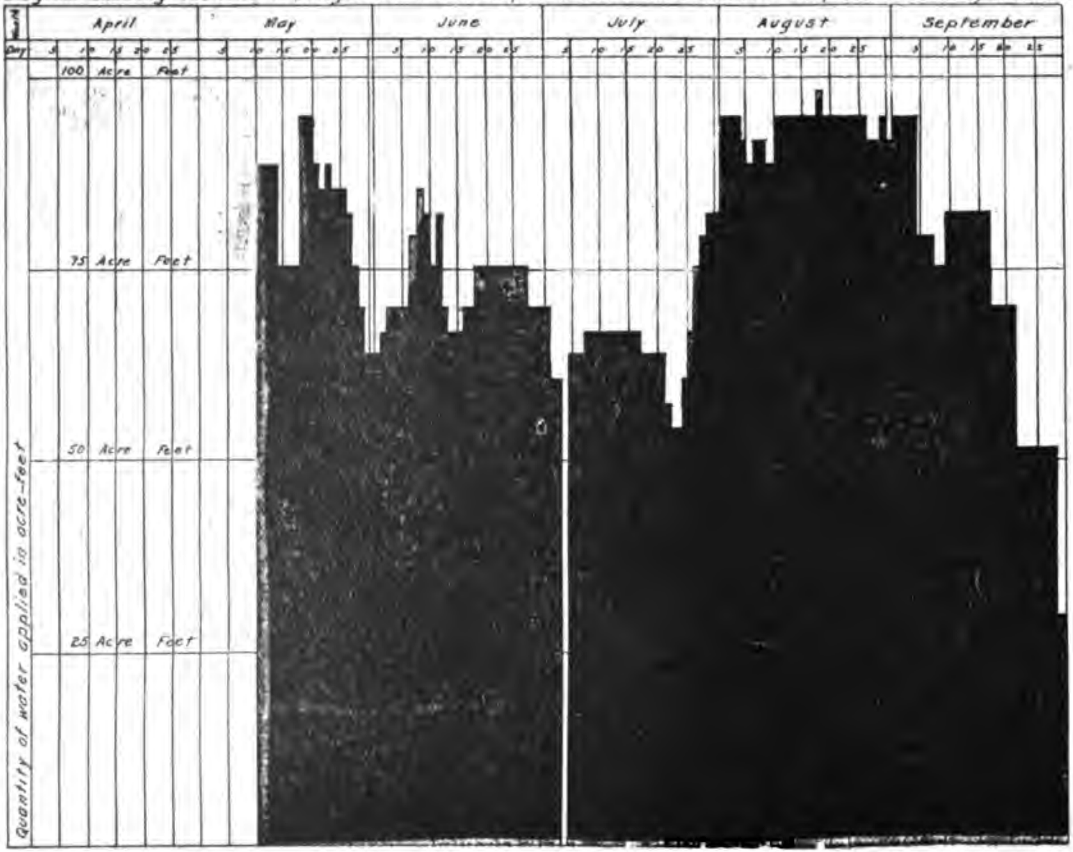
Daily discharge of the Republican Canal measured near the headgates, April 11 to September 30, 1902.

DAY	APRIL. Acre Feet.	MAY Acre Feet.	JUNE. Acre Feet.	JULY. Acre Feet.	AUGUST. Acre Feet.	SEPTEMBER. Acre Feet.
1	....	....	127.1	139.7	190.2	190.2
2	....	....	133.4	120.8	190.2	190.2
3	....	....	139.7	120.8	190.2	190.2
4	....	....	139.7	.....	190.2	190.2
5	....	....	139.7	127.1	183.8	158.6
6	....	....	139.7	127.1	177.5	158.6
7	....	....	145.7	127.1	183.8	158.6
8	....	....	158.6	133.5	183.8	150.9
9	....	....	170.9	133.5	177.5	150.9
10	....	....	164.8	133.5	177.5	164.8
11	....	177.5	150.9	133.5	190.2	164.8
12	....	177.5	164.8	133.5	190.2	164.8
13	....	177.5	139.7	133.5	190.2	164.8
14	....	177.5	133.4	133.5	190.2	164.8
15	....	150.9	133.4	133.5	190.2	164.8
16	....	150.9	133.4	133.5	190.2	164.8
17	....	150.9	139.7	133.5	190.2	164.8
18	....	150.9	139.7	127.1	196.3	139.7
19	....	190.2	150.9	127.1	190.2	139.7
20	....	190.2	150.9	127.1	190.2	139.7
21	....	177.5	150.9	127.1	190.2	139.7
22	....	170.9	150.9	114.6	190.2	102.1
23	....	177.5	150.9	108.4	190.2	102.1
24	....	170.9	150.9	108.4	190.2	102.1
25	....	170.9	150.9	120.8	190.2	102.1
26	....	170.9	150.9	133.4	190.2	102.1
27	....	164.8	150.9	150.9	183.8	102.1
28	....	150.9	139.7	158.6	183.8	102.1
29	....	139.7	139.7	164.8	190.2	60.5
30	....	127.1	139.7	164.8	190.2	60.5
31	....	127.1	.....	164.8	183.8	.....

DUTY OF WATER UNDER REPUBLICAN CANAL.

		1901.	1902.
Area irrigated	acres	4,105	4,850
Water used	acre-feet	13,758	17,856
Average depth of water applied	feet	3.35	3.68
Duty of water in acres per miner's inch	acres	2.02	2.22

Diagram showing the time of irrigation and the depth of water used from the Republican Ditch, Hamilton, Montana.



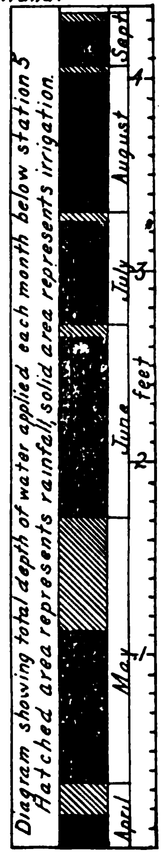


PLATE II

DUTY OF WATER UNDER THE HEDGE CANAL, RAVALLI COUNTY, MONTANA.

The Hedge canal diverts water from the Bitter Root river a number of miles above the Republican canal. This canal is 24 miles long and irrigated during the past season 5,420 acres of first bench lands immediately above the areas covered by the Republican canal. The upper portion skirts the river and consists chiefly of flumes and inverted siphons. There are about five miles of flumes and 1,100 feet of redwood stave pipe. The greatest flow during the season of 1902 was 5,092 miners' inches, and occurred June 21 and 22.

Plate III shows by diagrams the quantity of water flowing past the upper measuring flume and also the depths of water applied to the irrigated land each month.

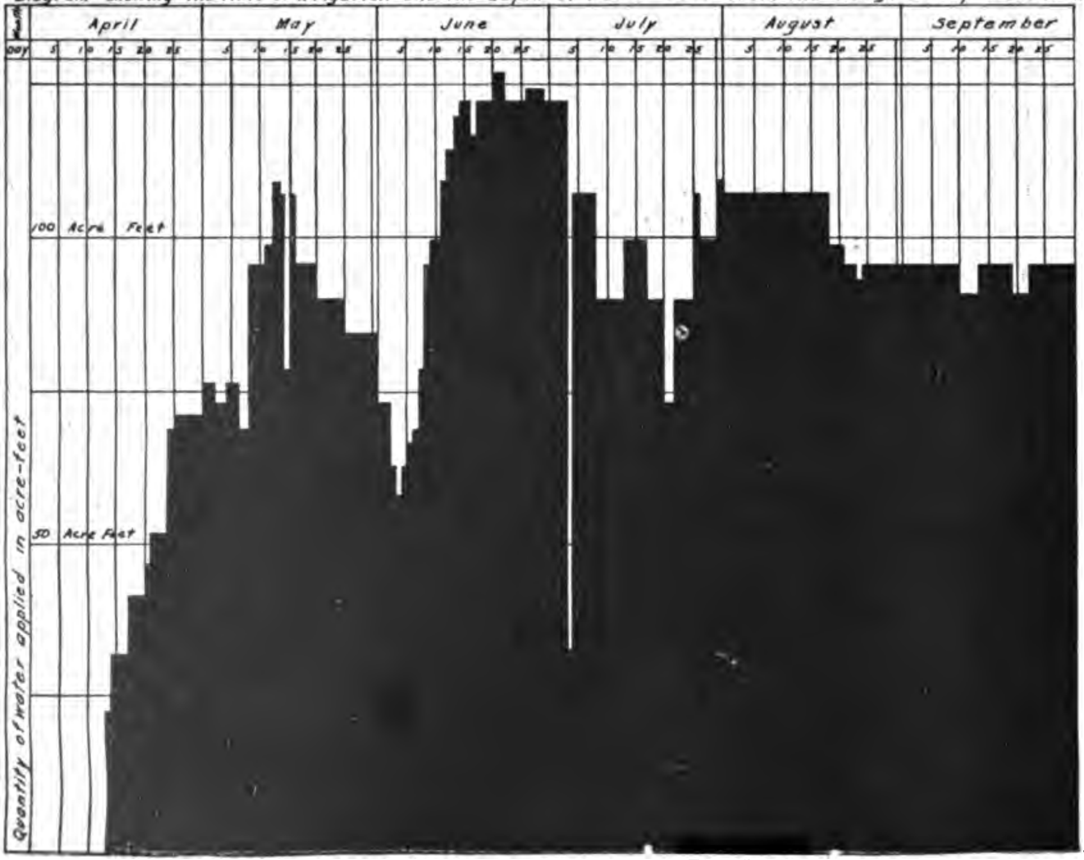
DAILY DISCHARGE OF THE HEDGE CANAL, AS MEASURED IMMEDIATELY BELOW THE WASTE-GATES, WHICH ARE LOCATED ABOUT 3,000 FEET BELOW THE HEAD-GATES. APRIL 14 TO SEPTEMBER 30, 1902.

Day	APRIL Acre-Feet.	MAY Acre-Feet.	JUNE Acre-Feet.	JULY Acre-Feet.	AUGUST Acre-Feet.	SEPT. Acre-Feet.
1	....	151.7	146.3	242.1	211.2	189.8
2	....	151.7	146.3	242.1	211.2	189.8
3	....	146.3	124.9	242.1	211.2	189.8
4	....	146.3	113.8	62.8	211.2	189.8
5	....	151.7	124.9	211.2	211.2	189.8
6	....	151.7	130.1	211.2	211.2	189.8
7	....	135.7	135.4	211.2	211.2	189.8
8	....	189.8	155.3	211.2	211.2	189.8
9	....	189.8	189.8	178.5	211.2	189.8
10	....	189.8	198.4	178.5	211.2	189.8
11	....	189.8	198.4	178.5	211.2	178.5
12	....	191.7	216.4	178.5	211.2	178.5
13	....	216.4	226.7	178.5	211.2	178.5
14	46.2	211.2	237.0	198.4	211.2	189.8
15	62.8	155.3	242.1	198.4	211.2	189.8
16	62.8	211.2	242.1	198.4	211.2	189.8
17	62.8	189.8	231.8	198.4	211.2	189.8
18	81.9	189.8	242.1	178.5	211.2	189.8
19	81.9	189.8	242.1	178.5	194.7	189.8
20	81.9	189 8	242.1	178.5	194.7	178.5
21	92.2	178.5	252.5	146.3	194.7	178.5
22	103.3	178.5	252.5	146.3	189 8	178.5
23	103.3	178.5	242.1	178.5	189.8	189.8
24	103.3	178.5	242.1	178.5	183.0	189.8
25	135.1	178.5	242.1	211.2	189.8	189.8
26	140.8	167.8	242.1	198.4	189.8	189.8
27	140.8	167.8	247.3	198.4	189.8	189.8
28	140.8	167.8	247.3	198.4	189.8	189.8
29	140.8	167.8	247.3	216.4	189.8	189.8
30	140.8	167.8	242.1	216.4	189.8	189.8
31	....	167.8	....	211.2	189.8	....

DUTY OF WATER UNDER THE HEDGE CANAL.

		1901.	1902.
Area irrigated	acres	5,260	5,420
Water used	acre-feet	20,883	31,274
Average depth of water applied	feet	3.97	5.76
Duty of water in acres per miner's inch	acres	1.64	1.46

Diagram showing the time of irrigation and the depth of water used from the Hedge Ditch, Hamilton, Montana.



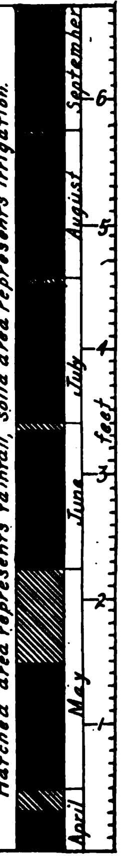


Diagram showing total depth of water applied each month.
Hatched area represents rainfall, solid area represents irrigation.

PLATE III

DUTY OF WATER UNDER THE WARD CANAL.

The Ward canal diverts water from the Skalkaho creek, a tributary of the Bitter Root river. In 1902 this canal irrigated 3,985 acres of bench lands located above the Hedge canal. It is 7 miles long, has a bottom width of about 8 feet and is built on a grade of 5.28 feet per mile. The greatest flow during 1902 was 2,800 miners' inches and occurred June 23 to July 3.

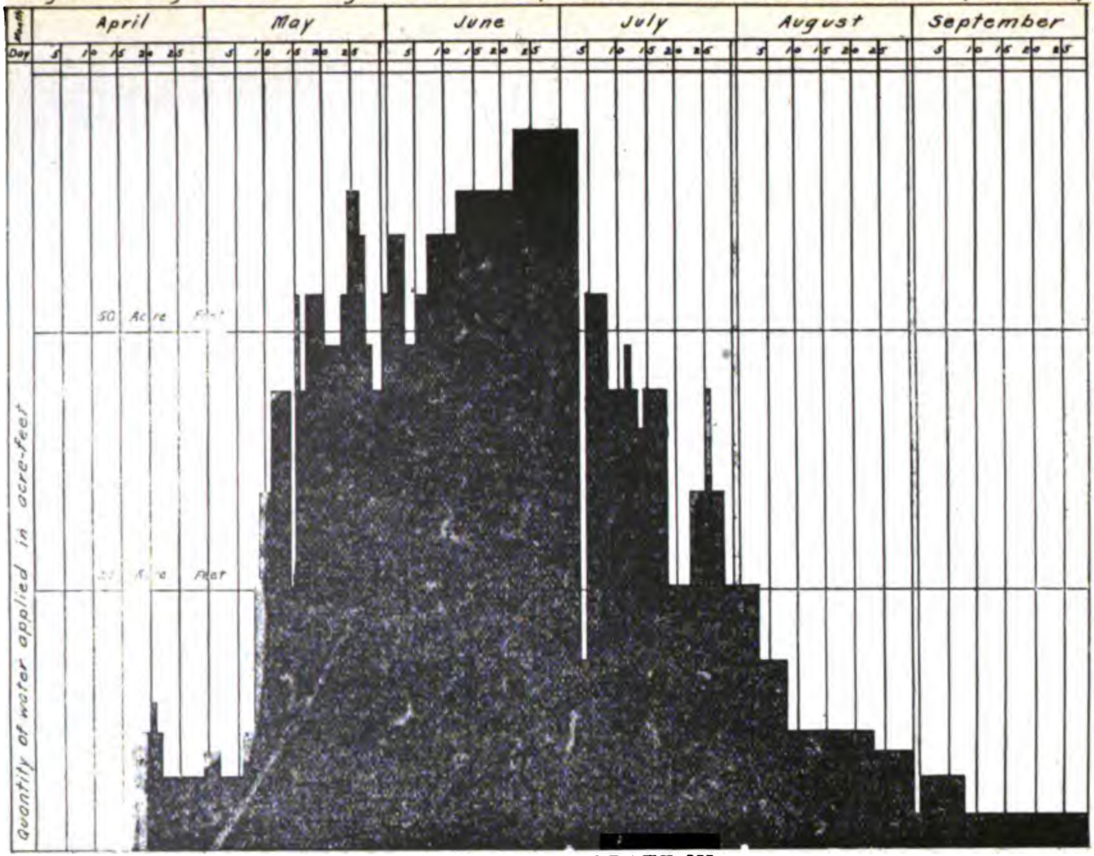
Plate IV shows by means of a diagram the daily discharges for 1902 and the average depths of water applied each month of the irrigation season.

DAILY DISCHARGE OF THE WARD CANAL, AS MEASURED AT THE OLD FLUME NEAR THE HEAD ON SKALKAHO CREEK, APRIL 18 TO SEPTEMBER 30, 1902.

Day	April. Acre-Feet.	May. Acre-Feet.	June. Acre-Feet.	July. Acre-Feet.	August. Acre Feet.	Sept. Acre-Feet.
1	....	17.6	118.4	138.8	51.7	13.2
2	....	17.6	118.4	138.8	51.7	13.2
3	....	13.2	118.4	138.8	51.7	13.2
4	....	13.2	97.7	35.9	35.9	13.2
5	....	13.2	97.7	107.9	35.9	13.2
6	....	13.2	107.9	107.9	35.9	13.2
7	....	22.8	107.9	107.9	35.9	13.2
8	....	22.8	118.4	107.9	35.9	13.2
9	....	51.7	118.4	88.2	22.8	6.7
10	....	69.4	118.4	88.2	22.8	6.7
11	....	69.4	118.4	88.2	22.8	6.7
12	....	88.2	118.4	97.7	22.8	6.7
13	....	88.2	128.3	88.2	22.8	6.7
14	....	88.2	128.3	81.6	22.8	6.7
15	....	51.7	128.3	88.2	22.8	6.7
16	....	107.9	128.3	88.2	22.8	6.7
17	....	88.2	128.3	88.2	22.8	6.7
18	22.8	107.9	128.3	88.2	22.8	6.7
19	22.8	107.9	128.3	51.7	22.8	6.7
20	22.8	107.9	128.3	51.7	22.8	6.7
21	29.1	97.7	128.3	51.7	22.8	6.7
22	22.8	97.7	128.3	51.7	22.8	6.7
23	13.2	97.7	138.8	69.4	22.8	6.7
24	13.2	107.9	138.8	69.4	17.6	6.7
25	13.2	128.3	138.8	69.4	17.6	6.7
26	13.2	128.3	138.8	88.2	17.6	6.7
27	13.2	118.4	138.8	69.4	17.6	6.7
28	13.2	97.7	138.8	69.4	17.6	6.7
29	13.2	88.2	138.8	51.7	17.6	6.7
30	17.6	88.2	138.8	51.7	17.6	6.7
31	....	107.9	....	51.7	6.7	....

DUTY OF WATER UNDER WARD CANAL.		1901.	1902.
Area Irrigated	acres	3.587	3.985
Water used	acre feet	8.626	9.933
Average depth of water applied	feet	2.41	2.49
Duty of water in acres per miner's inch	acres	2.81	3.30

Diagram showing the time of irrigation and the depth of water used from the Ward Ditch, Hamilton, **Montana**.



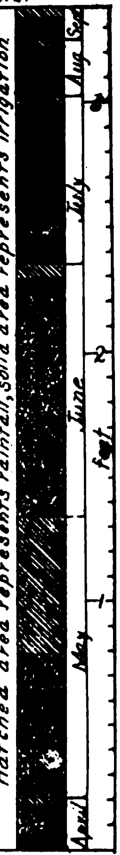


Diagram showing total depth of water applied each month.
Hatched area represents rainfall, solid area represents irrigation.

PLATE IV.

DUTY OF WATER UNDER SKALKAHO CANAL.

This canal, which is also supplied from Skolkaho creek is about 7 miles long, of which 2½ miles consist of flumes 4 feet 8 inches wide inside, by 2 feet 8 inches high. The grade is 5.28 feet per mile throughout. The greatest flow for the season of 1902 was 2,796 miners' inches and occurred July 1 and 2.

The diagram illustrating the flow on Plate V indicates considerable fluctuation in the flow.

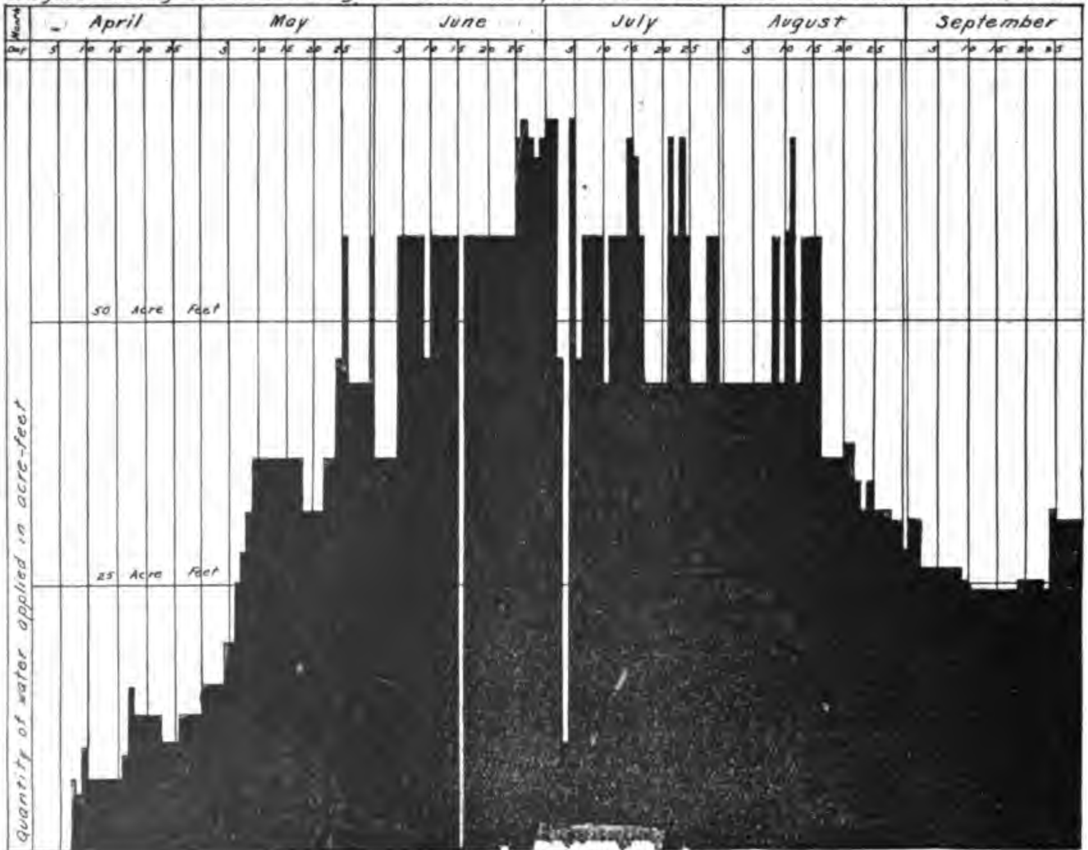
DAILY DISCHARGE OF SKALKAHO CANAL, AS MEASURED JUST ABOVE THE UPPER SIPHON AND ABOUT TWO MILES BELOW THE HEAD, APRIL 8 TO SEPTEMBER 30, 1902.

DAY	APRIL. Acre-Feet.	MAY. Acre-Feet.	JUNE. Acre-Feet.	JULY. Acre-Feet.	AUGUST. Acre-Feet.	SEPT. Acre-Feet.
1	....	30.1	73.3	138.6	82.3	61.2
2	....	30.1	73.3	138.6	82.3	61.2
3	....	30.1	73.3	91.2	82.3	54.3
4	....	30.1	73.3	22.3	82.3	54.3
5	....	39.1	120.0	138.6	82.3	54.3
6	....	39.1	120.0	91.2	82.3	54.3
7	....	50.9	120.0	120.0	82.3	54.3
8	13.2	57.7	120.0	120.0	82.3	54.3
9	10.1	64.6	120.0	120.0	120.0	54.3
10	19.2	73.3	91.2	120.0	82.3	50.9
11	13.2	73.3	120.0	82.3	120.0	48.0
12	13.2	73.3	120.0	120.0	134.4	48.0
13	13.2	73.2	120.0	120.0	82.3	48.0
14	13.2	73.3	120.0	120.0	120.0	48.0
15	13.2	73.3	120.0	134.4	120.0	48.0
16	13.2	73.3	....	130.1	120.0	48.0
17	17.4	73.3	120.0	120.0	73.3	48.0
18	30.1	73.3	120.0	82.3	73.3	48.0
19	25.9	64.6	120.0	82.3	73.3	48.0
20	25.9	64.6	120.0	82.3	73.3	50.9
21	25.9	64.6	120.0	82.3	77.7	50.9
22	25.9	64.6	120.0	134.4	77.7	50.9
23	25.9	73.3	120.0	120.0	68.8	50.9
24	22.3	73.3	120.0	134.4	64.6	48.0
25	22.3	91.2	120.0	120.0	68.8	64.6
26	22.3	120.3	134.4	82.3	64.6	61.2
27	25.9	82.3	138.6	82.3	64.6	61.2
28	25.9	82.3	134.4	82.3	64.6	61.2
29	25.9	82.3	130.1	120.0	61.2	61.2
30	25.9	82.3	134.4	120.0	61.2	61.2
31	....	120.0	....	82.3	57.7	....

DUTY OF WATER UNDER SKALKAHO CANAL.

		1901.	1902.
Area Irrigated	acres	1,600	1,975
Water used	acre-feet	7,494	13,423
Average depth of water applied	feet	4.68	6.79
Duty of water in acres per miner's inch	acres	1.40	1.21

Diagram showing the time of irrigation and the depth of water used from the Skalkaho Ditch, Hamilton, Montana.



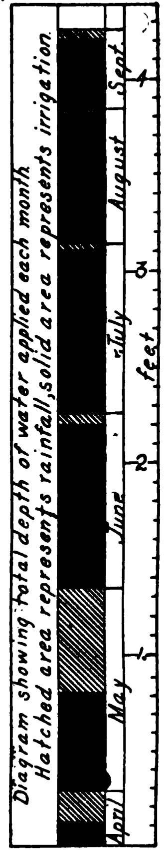


PLATE V

DUTY OF WATER UNDER GIRD CREEK CANAL.

The entire flow of Gird Creek is utilized for irrigation purposes during the summer months by means of two canals. Of these South Gird canal is the higher and irrigates lands beyond the end of the Skalkaho canal. South Gird canal, or ditch, is six feet wide on the bottom, two feet deep and is built on a grade of 5.28 feet per mile. North Gird canal is of about the same dimensions and irrigates the lands lying north of Gird Creek and above the Ward canal. During the past season the maximum flow of the North canal was 1,128 miners' inches and of the South canal 1,660 miners' inches.

The following table with the accompanying diagram represents the discharge of South canal for 1902, while the remaining table gives the duty of water under the North canal.

DAY	APRIL. Acre-Feet.	MAY. Acre-Feet.	JUNE. Acre-Feet.	JULY. Acre-Feet.	AUG. Acre-Feet.	SEPT. Acre-Feet.
1	....	21.62	65.26	73.79	56.43	56.43
2	....	21.62	73.79	73.79	65.26	56.43
3	....	21.62	73.79	73.79	65.26	56.43
4	....	21.62	78.15	.....	56.43	56.43
5	...	21.62	82.32	78.15	65.26	56.43
6	....	30.35	78.15	82.32	73.79	.43
7	....	30.35	78.15	78.15	73.79	30.35
8	....	30.35	82.32	73.79	82.32	30.35
9	7.79	30.35	78.15	65.26	82.32	30.35
10	8.62	30.35	73.79	30.35	73.79	30.35
11	7.79	65.26	73.79	30.35	73.79	30.35
12	7.79	65.26	73.79	39.17	73.79	30.35
13	7.76	65.26	73.79	47.78	82.32	15.51
14	4.49	65.26	82.32	47.78	73.79	15.51
15	4.46	65.26	82.32	47.78	73.79	30.35
16	4.46	65.26	82.32	39.17	73.79	30.35
17	6.84	76.27	73.79	39.17	65.26	30.35
18	11.70	76.27	73.79	39.17	65.25	30.35
19	12.06	65.26	73.79	39.17	65.26	30.35
20	15.51	65.26	73.79	39.17	65.26	30.35
21	15.51	65.26	73.79	39.17	65.26	30.35
22	21.62	73.79	73.79	47.78	65.26	30.35
23	21.62	73.79	73.79	47.78	65.26	30.35
24	15.51	73.79	82.32	39.17	65.26	30.35
25	15.51	73.79	82.32	39.17	56.43	39.17
26	15.51	65.26	73.79	47.78	56.43	39.17
27	21.62	65.26	82.32	47.78	56.43	39.17
28	21.62	73.79	82.32	47.78	56.43	39.17
29	21.62	82.32	82.32	5.16	56.43	21.62
30	21.62	73.79	78.15	5.16	56.43	21.62
31		73.79		3.97	47.78	.

DUTY OF WATER UNDER THE NORTH GIRD CREEK CANAL.

		1901.	1902.
Area irrigated	acres	1,211	1,345
Water used	acre-feet	1,759	4,710
Average depth of water applied	feet	1.45	3.50
Duty of water in acres per miner's inch	acres	2.56	2.04

Diagram showing the time of irrigation and the depth of water used from the Gird Creek Ditch, Hamilton, Montana.

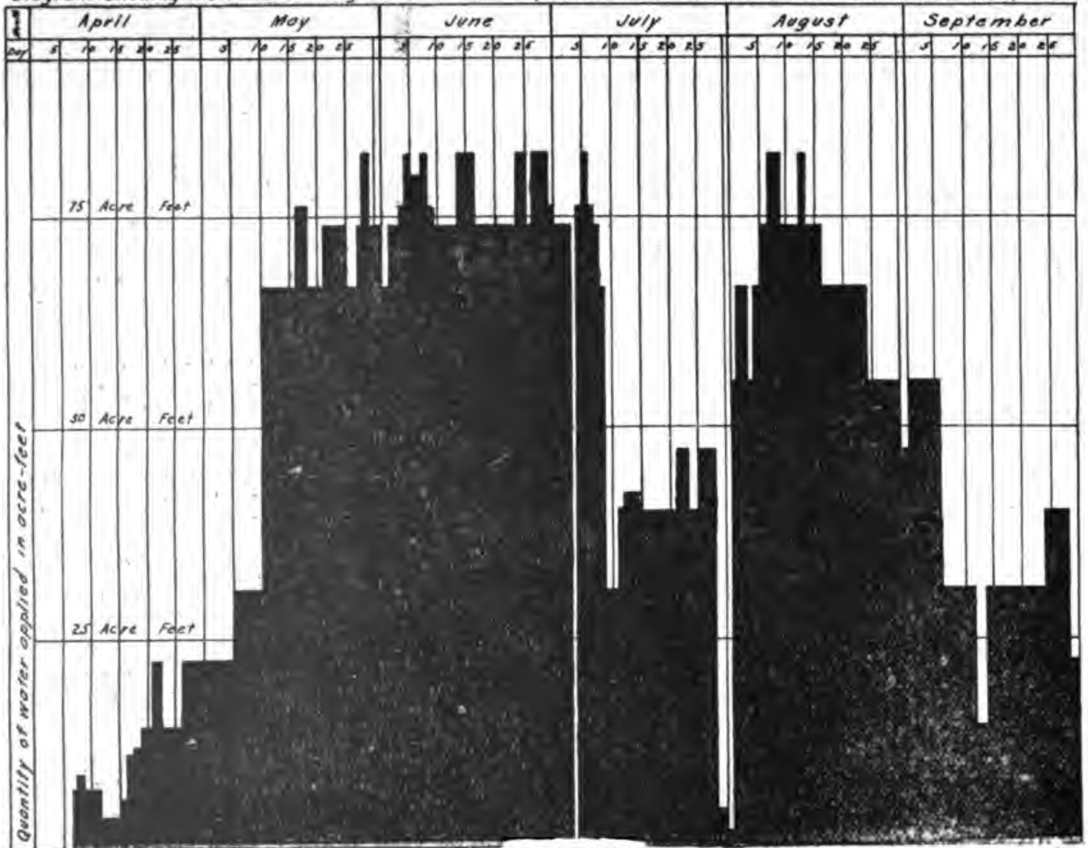


PLATE VI

DUTY OF WATER IN GALLATIN VALLEY.

During the past four years the quantities of water used on the farms watered by the Middle Creek Canal have been measured. In 1902 the investigations were extended to include the West Gallatin Irrigation Company's canal and the Kughen, Weaver and Stone, and Monforten ditches, the combined flow of which irrigates about 7,800 acres. Only the results of the Middle Creek Canal are given in this bulletin.

DUTY OF WATER UNDER MIDDLE CREEK CANAL.

This canal taps Middle Creek at a point about 3 miles below the canyon, extends in a northeasterly direction for a distance of about 5 miles and irrigates the

DAILY DISCHARGE OF MIDDLE CREEK CANAL, AS MEASURED NEAR THE HEADGATES, FOR THE SEASON OF 1902.

Date.	May.		June.		July.		August.	
	Miner's inches.	Acre feet.	Miner's inches.	Acre feet.	Miner's inches.	Acre feet.	Miner's inches.	Acre feet.
1	....	....	1508.4	74.8	1262.4	62.5	886.8	43.9
2	....	....	1200.0	59.4	1161.2	57.5	818.8	40.6
3	....	....	1256.4	62.3	804.8	39.9	792.0	39.2
4	....	....	1684.8	83.5	564.0	27.9	801.6	39.7
5	....	....	1975.2	97.9	444.0	22.0	747.2	37.0
6	....	....	2021.6	100.4	388.0	19.2	754.8	37.4
7	....	....	2287.6	113.4	431.2	21.4	751.6	37.2
8	....	....	2426.2	120.3	551.2	27.3	795.6	39.4
9	....	....	2599.6	128.9	734.0	36.4	811.2	40.2
10	....	....	3170.8	157.2	788.0	38.7	764.8	37.9
11	....	....	3164.0	157.2	772.2	38.2	766.4	38.0
12	....	....	3150.4	156.2	867.2	43.0	804.4	39.8
13	....	....	3260.0	161.6	933.6	46.2	834.8	41.4
14	....	....	2422.4	120.1	996.0	49.3	710.8	35.2
15	....	....	2299.6	114.3	1114.0	56.7	842.0	41.7
16	....	....	2159.6	107.1	1194.4	59.2	833.2	41.3
17	....	....	1979.6	98.1	1268.0	62.8	862.0	42.7
18	....	....	1443.2	71.5	1162.4	57.6	792.0	39.2
19	....	....	1306.8	64.7	972.0	48.2	645.6	32.0
20	....	....	1357.2	67.3	893.6	44.3	667.2	33.0
21	....	....	1357.6	67.3	924.4	45.8	621.6	30.8
22	....	....	1807.6	89.6	936.4	46.4	619.6	30.7
23	....	....	2510.8	124.7	958.8	47.5	350.0	17.3
24	....	....	2663.2	132.0	996.8	49.4	....	....
25	....	....	2548.4	126.3	1001.2	49.6	....	....
26	....	....	2387.6	118.4	936.8	46.4	....	....
27	110.4	5.4	2167.2	107.4	878.0	43.5	....	....
28	721.6	25.7	1466.4	72.7	854.8	42.3	....	....
29	1307.2	64.8	1372.8	68.0	844.8	41.9	....	....
30	1544.0	76.5	1420.4	70.4	919.2	45.6	....	....
31	1821.2	90.3	....	....	909.2	45.0	....	....
		262.7		3,094.3		1,363.0		856.6

PLATE VII.

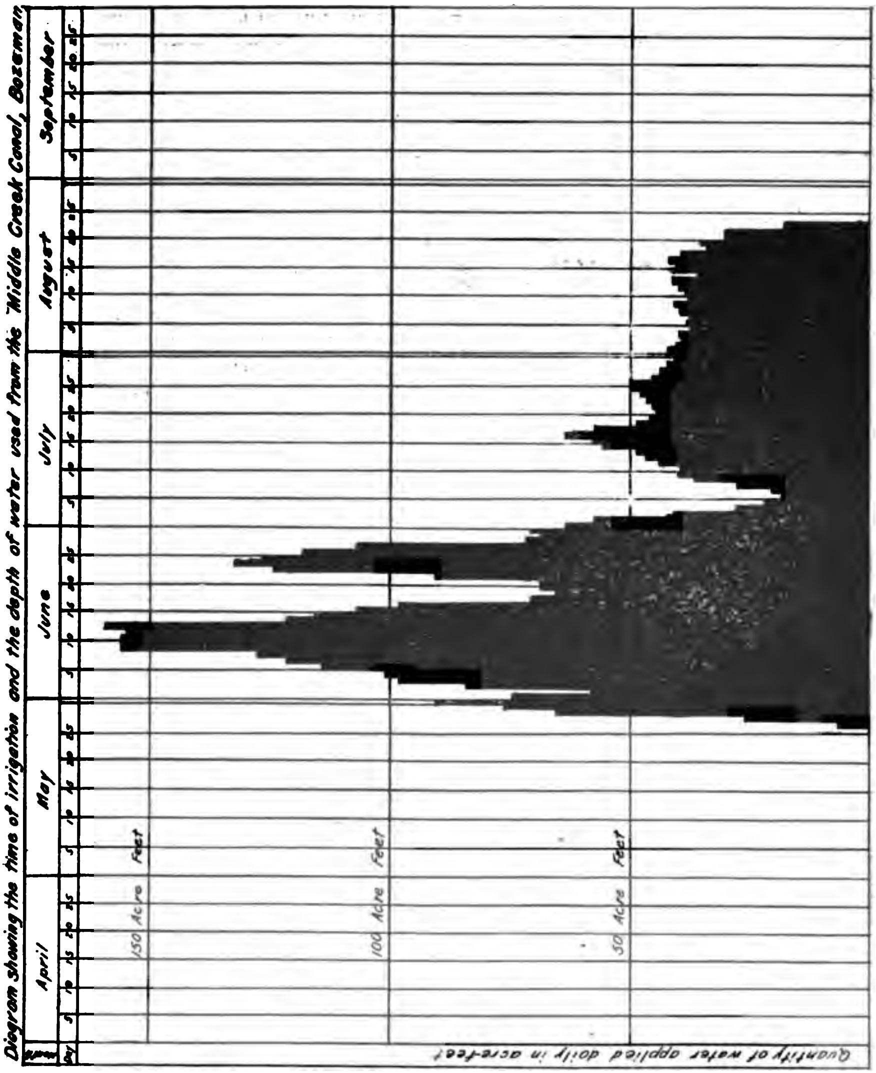


Diagram showing the time of irrigation and the depth of water used from the Middle Creek Canal, Bozeman
April
May
June
July
August
September
150 Acre Feet
100 Acre Feet
50 Acre Feet
Quantity of water applied daily in acre-feet

farms south-west of Bozeman, including that of the Experiment Station. In the spring of 1899 a rating station was established just below the main headgates and the daily discharge has been determined for four successive seasons. In 1899 the area irrigated was obtained by interviewing each stockholder, whose statement was taken as the acreage on his farm watered from this source. The same acreage was used in 1900 but in 1901 a new census was taken which showed that the extent of land irrigated had decreased. During the past season Assistant Professor Baker, with the aid of several advanced students in civil engineering, made a complete plane table survey of Middle Creek and the district irrigated by means of ditches from this source. The acreage under this canal as contained in the following table may therefore be relied on. In 1899, 1135 acres were summerfallowed under this canal while in 1902 there were only 344 acres. A highly profitable clover crop being in nearly every case substituted for the unprofitable fallow-land

DUTY OF WATER UNDER MIDDLE CREEK CANAL.

	1899.	1900.	1901.	1902.
Area irrigated.......................acres	3,853	3,853	3,186	4,828
Water used.........................acre-feet	8,074	7,324	7,454	5,577
Average depth of water applied.....feet	2.10	1.90	2.34	1.15
Duty of water in acres per miner's inch...........................acres	2.19	2.75	2.26	3.78

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BULLETIN NO. 44

MONTANA AGRICULTURAL

Experiment Station

OF THE

AGRICULTURAL COLLEGE OF MONTANA

APPLE GROWING IN MONTANA

BOZEMAN, MONTANA, FEBRUARY, 1903

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Bozeman, Montana.

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Bozeman, Montana.

Notice.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 44 - - - - February, 1903

APPLE GROWING IN MONTANA.

R. W. FISHER.

Introduction.

The people outside the natural fruit districts are fast realizing the fact that apples can be successfully grown in the higher altitudes of this state, and in many places where was once a barren waste, or cattle range, are now to be found young orchards, which are surely destined to produce fruit, and become a source of revenue to the farm.

The failures of the past in growing apple trees have been due to one or several of the following reasons:

1. Tender or worthless varieties.
2. Uncongenial soils.
3. Poor planting.
4. Insufficient or indifferent care after planting, or many causes that result in failure, in even more favored localities than ours.

However these attempts, although a failure was the immediate result, have been of very great value to the interests of horticulture, in that they have shown the varieties that can be successfully grown, and the methods best to pursue in the growing of these varieties.

With the exception of the Bitter Root valley, and possibly the Flathead and Yellowstone valleys, the question is, and has been,

what varieties can be grown, and not; what are the best varieties to grow?

From the experience of the horticulturists throughout the State, and the results obtained from the Experiment Station orchard and nursery, we are able to name the varieties best adapted to the different parts of the State, and also the methods of planting, cultivation, irrigation, et cetera, best to pursue. And with the present knowledge, every farmer in the State below an altitude of 5,000 feet, can, and should, grow at least enough fruit to supply his own table.

Soils and Slopes.

Any soil that produces a good farm crop, will also grow good apples, if the proper precautions are taken to keep it in good condition. Strong gumbo or alkaline soils should not be planted to orchard trees, nor soils underlaid near the surface with hard-pan.

While there is a preference for a northern slope, yet, the fact that one is not procurable should not deter one from planting trees, if he has a good soil and other favorable conditions. In very exposed and windy places wind-breaks are undoubtedly of value, especially after the trees come into bearing, as they break the force of the wind and prevent the fruit from falling before it is mature.

Preparation of the Ground.

The orchard site should be in perfect condition for planting before any trees are set out, as it is a very hard matter to correct evils in grading and plowing after the trees are in their places. Some grain or forage crop, or preferably a crop that requires deep and continuous cultivation is desirable to grow for a year or two previous to planting the trees. It is of first importance that the ground is properly graded so that irrigation water can be easily applied, for it is almost impossible to do this after the trees have been set out.

If the trees are to be planted in a heavy soil, some precautions should be taken to break up the subsoil thoroughly. Placing dynamite in the holes where the trees are to stand has been tried with

success; but a liberal application of barn-yard manure, to give the necessary humus, and deep subsoiling for a year or two previous to planting, would probably give better results.

In localities where the water-level comes within eight or ten feet of the surface, and remains for any length of time, especially in the summer and fall, drainage is necessary, and unless this can be easily accomplished, it would probably be a loss of time and money to attempt to grow an orchard on such land.

Planting the Tree.

The ground being in good condition, the next consideration is the planting of the tree, and on this depends much of the future usefulness of the orchard.

In all parts of the state, with the possible exception of the Bitter Root valley, spring planting will give the best results, and the earlier in the spring after the frost is out of the ground the better.

Have the holes large enough to receive the roots without in any way cramping them, and deep enough so that the tree will stand a trifle deeper than it was in the nursery. It is also a good plan, if the ground is not very loose, to dig up four or five inches of loose soil in the bottom of the hole.

When the tree is in place, fill in around the roots with fine soil, being careful that there are no air spaces left near the roots. Fill the hole nearly full, and then tamp down firmly, and if the soil is inclined to be dry, water should be added and allowed to soak away into the ground before the top soil is filled in, which should be left in a loose condition, to act as a mulch, thus preventing undue evaporation and retaining the soil moisture.

Trim off all broken or lacerated roots, as a smooth cut heals over more readily and induces new roots to form. And since a good part of the root system has been lost in the operation of digging, the top will have to be pruned back to regain the balance of top and root. In three year old trees that have already been "headed" or formed in the nursery, all the twigs or limbs should be cut back to 4 or 5 buds, and allowed to develope to their full capacity until the following year. With a one year old tree, ie., with a top of one year's growth

on a two year old root, (which is the best size tree to plant, all things considered), it should be cut back to a prominent bud, at the distance from the ground it is desired to have the tree branch. From twenty-four to forty-two inches is the best height to head the trees, depending on the variety, location, and one's ideal of what a tree should be.

Laying off the Ground.

The land should be laid off in straight rows, from eighteen to twenty-five feet apart, and the exact location of each tree determined before the holes are dug, as straight rows of trees add much to the beauty of an orchard, and also facilitates harvesting and spraying.

Where a large number of trees are to be planted, Mr. O. S. Chilcott, of Rockvale, has a very good method of laying off the ground and digging the holes. He says: "Instead of digging the holes, I plow them. First, I lay off the field with light furrows running crossways, for guides to plant by, then these are crossed by furrows running the way we irrigate, made with a heavy team and plow. When the furrow is run I take out of the bottom another one by straddling it with the team and having the driver stand on the end of the plow beam and double-trees. This will enable one to take a full furrow out of the bottom of the first one, making it so deep that the tree holes are practically dug, and the cross furrows indicate exactly where the trees are to stand. Now the planter can go ahead without measuring or sighting. He simply puts a tree at the intersection of the furrows, and if the furrows have been properly made, the trees will be in perfectly straight rows."

Irrigation and Cultivation.

In most sections of the State, irrigation is essential to the best results, and in many places absolutely necessary in order to get a crop; and where irrigation is practiced, the trees should be given plenty of water during the spring and early summer, and by the first or fifteenth of July the water should be witheld. By doing this the trees will make a normal growth, and will have time to thoroughly ripen

their wood before freezing weather, thus being better able to stand the cold and fluctuations in temperature throughout the winter and early spring. When water is applied it should be given in sufficient quantity so that the ground is moistened deep enough to reach all the roots, otherwise it does but little good.

Where "clean cultivation" is practiced, (and this is undoubtedly the best method to pursue for at least the first four or five years), the orchard should be cultivated about every ten days throughout the growing season, and especially as soon after an application of water as is possible. Until the orchard is several years old it should be plowed each spring, being careful not to disturb the roots; and then cultivated with a disc or spring tooth harrow during the early part of the summer. After August 1st shallow cultivation once in ten days or two weeks is all that is necessary to keep down the weeds and retain the moisture in the soil.

Pruning.

The tree that was cut back at transplanting, will have formed the following year a large number of small shoots. From these select three to five of the strongest and best shaped limbs (cutting out all the rest), and at the same time taking care that they are evenly distributed around the tree, and form no crotches. After having decided upon the limbs intended to form the framework of the tree, shorten them back to within a foot of the main stem, always cutting to a strong bud. As a rule the weaker the growth the harder it ought to be cut back, as this will encourage wood-growth the following season.

The next years pruning is done along the same line, choosing the limbs that are to make the upward growth of the tree, and shortening the season's growth back some, observing always that there are no crotches or cross limbs left. The necessary pruning during the following years does not materially differ from that described for the second and third years.

The object should be to get a symmetrical low-headed tree, with no crotches or cross limbs, and without too much wood. The best time to do pruning in Montana, where wood growth is the first consideration, is in the winter or early spring. But of more importance

than the time is the way in which the pruning is done. Always make a smooth cut, and do not leave stubs sticking out from the side of a tree, expecting them to heal over. Make the cut as near the main limb as possible, and if large (from one to one and one-half inches and above), it is a good plan to cover the wound with white lead and linseed oil paint.

Varieties.

Practically all the varieties commonly grown in the United States have been tried in Montana, and from these have been selected those best suited to our conditions. Yet even in the same locality there is much difference of opinion as to the best apples to grow, either for home or market purposes, and it is not the object of this bulletin to attempt to determine those varieties, but rather to name the varities that have been grown successfully, and to give the comparative values of these apples for home or market uses.

For this purpose the following table, taken from the United States Department of Agriculture and used by the American Pomological Society in the description of fruits, is inserted in part:

Section 1.—APPLES. (Pyrus.)

SUBSECTION 1.—CRABS. (*P. BACCATA.*)*

[KEY—Size, scale 1 to 10: 1, very small; 10, very large. Form: c, conical; i, irregular; o, oblate; ob, oblong; ov, ovate; r, round. Color: g, green; r, red; ru, russet; s, striped; w, white; y, yellow. Flavor; a, acid; m, mild; s, sweet. Quality, scale, 1 to 10: 1, very poor; 10, best. Season: e, early; m, medium; l, late; vl, very late. Use: c, cider; d, dessert; k, kitchen; m, market. Abbreviations of names of places of origin: Am., America; Eng., England; Eur., Europe; Fr., France; Ger,; Germany; Holl., Holland; Ont., Ontario; Rus., Russia; Scot., Scotland.]

Name.	Description.							
	Size	Form.	Color.	Flavor.	Quality.	Season	Use.	Origin.
Gibb	6	o	yr	a	9	e	k	Wis.
Hyslop	6	r	r	a	3	em	km	Am?.
Martha	5	o	yr	a	5-6	e	k	Minn.
Orange	5	r	y	a	3-4	l	k	Am.
Transcendent	5	r	yr	a	5-6	e	km	Am.
Whitney No. 20	8	rc	r	m	8-9	em	dkm	Ill.

SUBSECTION 2.—APPLES. (P. MALUS).

Alexander	10	oc	yrs	ma	5	em	km	Rus.
Antonovka	6	ovc	y	ma	7	m	km	Rus.
Arkansas (Mam. Blk. Twig)	9	ro	yr	m	9	l	km	Ark.
Bailey Sweet	8-9	r	r	s	7-8	ml	dm	N Y.
Baldwin	7-8	roc	yr	m	5-6	vl	km	Mass.
Ben Davis	6-9	rov	yrs	m	4	l	m	Ky.?
Bethlehemite	5-6	oc	yrs	m	5-6	vl	dkm	Ohio.?
Bietigheimer	10	oc	wyr	m	4	em	m	Ger.
Blue Pearmain	9	rc	rs	m	6	l	dm	Am.?
Bough, Sweet	8	ov	y	s	8	e	d	Am.
Bullock (American Golden Russet)	4	rov	yru	m	8-9	l	d	N. J.?
Early Harvest	5-6	ro	ywr	ma	9	ve	dk	Am.
Early Strawberry	4	rc	yrs	m	6-7	e	dm	N. Y.
Esopus	8	obc	r	m	10	l	d	N. Y.
Fallawater	10	rc	ygr	m	4	l	m	Pa.
Fall Pippin	10	roc	yr	m	10	m	dk	Am.

*Includes such possible hybrids as strongly manifest Crab parentage.

Section 1.—APPLES (Pyrus)—Continued.

Subdivision 2.—APPLES. (P. MALUS,)—Continued.

Name.	Description.							
	Size.	Form	Color	Flavor	Quality.	Season	Use.	Origin
Fall Wine	7-8	ro	yrs	m	7-8	m	d	Am.?
Fameuse	5-6	ro	yrs	m	8-9	m	dm	Fr.?
Family	5-6	oc	yrs	m	5-6	em	d	Ga.
Gano	7-8	oi	yrs	m	5	ml	m	Mo.
Gideon	5-6	rc	y	a	5	e	k	Minn.
Golden Russet (N. Y.)	4-6	ro	yru	m	5-6	l	dm	Eng.
Golding (American Golden Pippin)	6-8	roc	yr	m	5-6	m	dk	Am.
Gravenstein	8-9	oi	yr	ma	5-6	em	dkm	Ger.
Gravenstein, Russian	8	c	rs	....	9	e	dm	Rus.
Haas (Fall Queen)	5-7	oc	gyr	m	4-6	em	km	Mo.
Hibernal	5-7	obc	rs	....	5	m	km	Rus.
Hubbardston	7-8	rov	yrs	m	8-9	l	dm	Mass.
Jefferis	5-6	oc	yrs	m	8-9	e	d	Pa.
Jonathan	5-6	rc	yr	m	8-9	l	dkm	N. Y.
Late Strawberry	5-6	rc	wrs	m	5-6	m	d	N. Y.
Lawver (Deleware Red Winter)	7-8	ro	r	m	5-6	vl	dm	Mo.
Limber Twig	6-7	roc	gyr	m	3-4	vl	m	N. C.
Longfield	5-6	rc	y	m	5-6	e	k	Rus.
McIntosh	6-7	ro	wyr	m	5-6	ml	dm	Ont.
McLellan	5-7	roc	yrs	m	5-6	m	d	Conn.
McMahon	7-8	ro	yw	m	3-4	m	dm	Wis.
Maiden Blush	5-6	o	yr	m	4-6	e	km	N. J.
Minkler	5-6	rc	gyr	m	6-8	l	m	Pa.
Missouri Pippin	6-8	ro	yrs	m	3-4	l	m	Mo.
Newtown Spitzenburg	5-6	oc	yrs	m	10	l	d	N. Y.
Northern Spy	8-9	roc	yrs	m	8-9	ml	dkm	N. Y.
Nortwestern Greening	8-9	rc	gy	m	6	l	km	Wis.
Oldenburg, Duchess of	5-6	o	yrs	a	4-5	e	km	Rus.
Pewaukee	7-8	ro	yrs	m	5-6	l	km	Wis.
Plumb Cider	5-6	rc	yrs	m	5-6	m	dm	Wis.?
Ralls Genet	7-8	oc	yrs	m	6-7	vl	m	Fr.
Red Astrachan	7-8	rc	rgy	a	5-6	e	km	Rus.
Red Canada.................a.	5-6	oc	yr	m	8-9	l	dm	Am.
Red June	3-4	ovc	r	m	5-6	ve	d	N. C.?
Rhode Island Greening	8-9	ro	gy	a	7	l	dkm	R. I.?
Romanite South	2-3	rc	yr	m	6-7	l	d	Am.?
Rome Beauty	8-9	rc	yrs	m	5-6	ml	dkm	Ohio
Scott Winter	5	rc	rs	a	7	l	km	Vt.
Shiawassee	5-6	o	wrs	m	7-8	m	dkm	Mich.
Smith Cider	7-8	roc	yr	m	5-6	l	km	Pa.
Summer Pearmain	5-6	oc	rru	m	10	em	d	Am.
Swaar	7-8	ro	gy	m	10	l	d	N. Y.
Tetofsky	5-6	roc	yrs	a	5-6	e	m	Rus.
Tompkins King	8-9	roc	yrs	m	8-9	l	dcm	N. J.
Twenty Ounce	10	r	yrs	m	6-7	ml	km	Conn.
Vandevere	5-6	o	yrs	m	5-6	ml	km	Del.
Virginia Greening	8-9	o	gyr	m	5-6	l	m	Am.
Wagener	6-7	ro	yrs	m	8-9	l	dm	N. Y.
Walbridge (Edgar Red Streak)	5-6	oc	yrs	m	5-6	l	m	Ill.
Wealthy	5-6	ro	yrs	m	6	m	dkm	Minn.
White Pearmain	7-8	robc	yr	m	5-6	l	dm	Am.?
Willow Twig	5-6	roc	yr	m	5-6	vl	m	Va.?
Winesap	5-6	rob	yr	a	7-8	l	dkm	N. J.
Wolf River	9-10	ro	wr	m	5-6	m	km	Wis.
Yellow Bellflower	8-9	obc	yr	a	7-8	l	dkm	N. J.
Yellow Newtown (Albemarle)	8-9	ro	yr	a	10	vl	dkm	N. Y.
Yellow Transparent	6-7	rc	y	a	7	e	km	Rus.
York Imperial	8-9	o	yrs	m	5-6	l	dm	Pa.

In order to learn the varieties that are best adapted, and most commonly grown in the State, letters were sent out inquiring of the prominent fruit-growers in the several fruit districts, the varieties best adapted to their paricular locality, and from these answers, the prospective apple grower may learn the varieties best to plant.

VARIETIES.

Yellowstone Valley.

From the Yellowstone valley, the varieties recommended by Mr. Olney Taylor of Park City, are in the order given:

Yellow Transparent	Wealthy,
N. W. Greening,	McIntosh Red,
Duchess de Oldenburg,	Ben Davis
Walbridge,	Alexander.

Crabs.

Transcendent,	Martha.

Mr. O. S. Chilcott, of Rockvale, says: "A great many varieties of apples have been planted here within the last few years, and practically all the trees seem to do well. I will not attempt to give a list of the varieties planted, but rather of those that have borne fruit. Those that have been most thoroughly tested and are recommended for general planting are marked."*

*Yellow Transparent,	*Duchess,.
*Wealthy,	August,
October,	Peter,
Gideon,	Hibernal,
Okabena,	Tetofsky,
Thompson's Seedling	N. W. Greening,
Fameuse, or Snow,	*Ben Davis,
Wine Sap,	*Gano,
Walbridge,	Wolf River,
Wagener,	Malinda,
Alexander,	Jonathan.

Crabs.

*Transcendent,	*Florence,
*Martha,	Whitney, No. 20,
White Arctic,	General Grant,
Hyslop.	

Northern Montana.

Mr. Peter Denny at Chinook, and Mr. W. M. Wooldridge at Hinsdale, have given the varieties grown in the northern part of the State, and while most all the orchards are as yet too young to bear fruit, yet the trees have been out long enough to test their hardiness, and since their altitude and growing season does not differ materially from other sections of the State where the same varieties have borne fruit, it might reasonably be expected that they also will mature their fruit.

Mr. Denny recommends the Wealthy, Duchess, and Gibb, and Transcendent crab. Mr. Wooldridge says: "Apple culture is meeting with success in the Milk River valley; the varieties which seem best adapted to the valley are, Duchess, Wealthy, Gano, Alexander, McIntosh Red, Bethel, and crabs."

Flathead Valley.

For the Flathead valley, O. C. Estey and Mr. J. C. Wood of Big Fork have given the varieties commonly grown in that district.

Mr. Wood says: "There are one hundred or more varieties grown here, out of which not more than a dozen or fifteen are satisfactory, and some of these only in favored localities. For general planting these are in the order named:

Yellow Transparent,	McIntosh Red,
Duchess,	W. W. Pearmain,
Alexander,	McMahon,
Wealthy,	Aiken,
Red June,	Rome Beauty,
Red Astrachon,	Fameuse,
Walbridge,	Gano.

Of the above named varieties, the Alexander is undoubtedly the best for extensive planting throughout the valley; while in the Lake region, the McIntosh Red leads all other varieties, with the Wealthy a close second."

Mr. O. C. Estey says: "The following list includes the varieties grown between Big Fork and the Reservation line, on the east side of Flathead Lake."

Aiken,	Alexander,
Babbit,	Duchess,
Esopus,	Gano,
Hubbardston,	Imperial,
McIntosh,	Minkler,
Family Favorite,	Newton,
Pewaukee,	W. W. Pearmain,
Fameuse,	Spencer,
Sweet Bough,	Autumn Strawberry,
Shackleford,	Northern Spy,
Ben Davis,	McMahon,
Red June,	Wine Sap,
Rome Beauty,	N. W. Greening,
Thompson's Seedling,	Wolf River,
Yellow Transparent,	Okabena,
Wealthy,	Delaware Red,

Crabs.

Transcendent,	Whitney, No. 20,
Martha,	Florence.

Among these he names as the best for general planting:

Aiken,	Alexander,
Duchess,	Esopus,
Gano,	McIntosh Red,
Fameuse,	Northern Spy,
Ben Davis,	Red June,
Rome Beauty,	Wealthy,
Yellow Transparent.	

Crabs.

Transcendent,	Martha,
Whitney, No. 20.	

Those that have been tried and discarded, are the Minkler, Pewaukee, Shackleford, N. W. Greening, and Florence crab.

Bitter Root and Plains Country.

Practically all the known varieties can be grown here with more or less success, and the question of best varieties is a very hard one to determine, the orchardists, who have been growing apples there for many years, not being settled upon this point.

Such varieties as King of Thompkins Co., Rome Beauty, Ben Davis, McIntosh Red, Bethel, Delaware Red, Alexander, Wealthy, Yellow Transparent, and many other common market apples are grown to perfection.

Gallatin Valley.

Over 175 varieties of apples have been tested in the Experiment Station orchard and nursery, and from this number, not more than 8 or 10 varieties are recommended, at present, for general planting. However, it should be understood that the Station orchard is in a very exposed location, and 4875 feet above sea level. Therefore it may be taken for granted that the varieties that are hardy here will grow in any other section of the state, with similar altitude, if planted in a good soil and given proper care.

The varieties found best suited to our conditions are:

Wealthy,	Duchess,
Yellow Transparent,	Okabena,
Longfield,	Hibernal,
Tetofsky,	Alexander,
N. W. Greening.	

Crabs.

Transcendent,	Greenwood,
Martha,	Hyslop,
Orange,	Whitney No. 20.

Conclusions.

With the foregoing list of varieties one is able to choose intelligently the varieties that are likely to grow in any district of the state. The same varieties that grow in the Bitter Root valley, for instance, are quite likely to do equally well in Missoula county, and locations with similar climatic conditions; and likewise, the varieties grown at the Station would be expected to grow in other

parts of the state, similarly located, with reference to the altitude, climatic conditions, etc.

The success in growing apples depends upon the following conditions:

Select three or four good varieties.

Plant properly.

Cultivate and irrigate thoroughly.

Prune systematically.

And if all these things are attended to, there is no good reason why apples of some variety cannot be grown in the coldest portions of Montana.

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MONTANA AGRICULTURAL

Experiment Station

OF THE

AGRICULTURAL COLLEGE OF MONTANA

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BOZEMAN, MONTANA, JUNE, 1903

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All communications for the Experiment Station should be addressed to the Director,

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Bozeman, Montana.

Notice.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the ation for that purpose.

Montana Experiment Station.

Bulletin No. 45 **June 1903**

THE LOCO AND SOME OTHER POISONOUS PLANTS IN MONTANA.

J. W. BLANKINSHIP.

INTRODUCTION.

Many plants, like animals, have some particular means of defense. Some are guarded by thorns and prickles, some have stinging or grandular hairs, or possess a bitter or unpalatable herbage; some are tough or woody, while still others secrete deadly poisons for protection and wreak swift vengeance upon such animals as have the hardihood to eat them. In many cases their indigestible nature simply causes bloat, in some others the poisons secreted are virulent and deadly. Loco is a narcotic and affects primarily the nervous system; larkspur and death camas paralyze the voluntary muscles, while water hemlock and lupine appear to affect both the brain and muscular system, and water hemlock at least also seems to have a corrosive action upon the mucous membrane of the digestive organs.

The annual losses in Montana resulting from stock eating these poisonous plants can not be far short of $100,000 and may even exceed that amount. Yet, when the total number and value of the stock of the state are taken into consideration, even this estimate will appear relatively small, being only about three tenths of one per cent of the whole or some two per cent of the increase. *

This subject of poisonous plants is becoming of more and more importance, because by the overstocking of the ranges, stock are compelled to resort to the more unusual and more unpalatable plants for food and consequently these cases of poisoning are becom-

* Assessed valuation for 1902:
Horses, 188,621, value, $5,378,381. Sheep, 4,718,610. value, $10,869,886.
Cattle, 751,040, value, $17,213,884. Total, 5,658,271, value, $43,456,601.

ing more numerous, and because of the present tendency of stockmen to purchase and fence the ranges for their exclusive use, so that, while formerly there was no disposition to do more than avoid the "poison localities," the increased value of these ranges and private ownership now demand methods for the destruction of these injurious plants, so as to prevent unnecessary losses.

A glance at the literature of the subject will show that considerable work has already been done by the various Experiment Stations of the Northwest and more recently the work has been taken up by the Division of Botany of the Department of Agriculture, under the direction of Mr. V. K. Chesnut and several important papers have been published. The history of the work at this Station begins in 1895 when Dr. F. W. Traphagen took up the subject from the chemical standpoint, being joined the following year by Dr. E. V. Wilcox, the Zoologist and Veterinarian of the Station, co-operating with Dr. Bird, then State Veterinarian. The work was continued by Dr. Wilcox till 1899, when he went to Washington and the investigations have since been mainly under direction of the Botanist. The results of these studies have been presented in bulletins 15 and 22 by Dr. Wilcox and in the present issue.

From the investigation of a large number of cases of stock poisoning it appears that some 95 per cent of such losses in this state is due to five or six species of plants, or more strictly, groups of related species; namely, the loco, lupine, water hemlock, death camas, larkspur and wild parsnip, and that while cases of poisoning by other plants may and doubtless do occur, these cases are relatively few and need not here be considered. The not infrequently fatal effects of alkali on the eastern ranges have been largely attributed to plant poisons and have served to swell the total and complicate the symptoms.

The object of this bulletin is to present a brief summary of our present knowledge of these poisonous plants—conclusions reached by the field-work of three seasons and from a study of the various bulletins and papers already published on the subject, in order that these plants may be recognized and the conditions under which the poisoning occurs be known, as well as the symptoms of such poisoning and the usual remedies. It must be remembered that as yet the exact symptoms of the different poisons in many cases have not been clearly determined, nor have efficient remedies been found, the subject being yet in the experimental stage, while for the successful solution of the various problems involved, the co-operation in experimental work of a veterinarian and a botanist with the aid of a chemist or pharmacist is necessary to secure the best results by the experimental feeding of these suspected plants in their various stages directly to the animals themselves, noting the quantity fed, the resulting symptoms and effects, as shown by examination after death, while later the work of seeking antidotes for these various poisons can

be undertaken. Work of this nature is expensive and can be performed only in localities where these plants grow, while as yet the desired co-operation of men and means has not been secured.

An attempt has been made to bring together at the end a brief synopsis of the symptoms of these poisons and the usual conditions when losses occur, in order that the stockman may be able to determine the cause of any case of poisoning that may arise.

There is also added a bibliography of the literature of the plants poisonous to stock in America, exclusive of the Fungi, as far as our library facilities here permit, and this may be of service to other investigators and stockmen who care to pursue the subject further. For the more exhaustive treatment of several phases of the subject, the stockmen of Montana are referred to the bulletin of Chesnut and Wilcox on the "Stock-Poisoning Plants of Montana" issued by the U. S. Department of Agriculture, to which we are indebted for figures 2, 3 and 6. Fig. 1 is from Vasey in the Report of the U. S. Commissioner of Agriculture for 1884, while the remaining figures are by students in this institution, figures 3 and 4 by Jacob Vogel and 6 by Amy M. Cooke.

Valuable assistance has also been rendered by Dr. M. E. Knowles, State Veterinarian, in the prosecution of this investigation, and I wish also to thank the many stockmen in the various parts of the state, who have aided me in this work, while without the efficient co-operation of the railways of the state, such work could hardly have been attempted.

CONDITIONS OF POISONING.

The investigations here undertaken seem to show that stock-poisoning by plants is more frequent in certain sections of the state, in certain seasons of the year and during certain weather conditions and a knowledge of these zones, seasons and conditions may aid in materially reducing the losses from this cause.

The chief poison zones of the state are nearly confined to the foothills of the various mountain ranges east of the Continental Divide and to the high bench lands of the plains eastward. There has been little complaint from the extreme eastern or western parts of the state. These poison zones are characterized by the abundance of the larkspurs, lupines, death camas and wild parsnip, which are far less frequent or entirely absent further east or west. The loco zone is a well defined section near the central part of the state, while the water hemlock is frequent along streams from the foothills westward, being rare or entirely absent in the eastern plains. It is not the presence, but the abundance of these various plants, that determines these poison zones. The death camas is found in nearly every part of the state, but is abundant only in certain localities; the loco weed

occurs throughout the plains region of the United States and Canada, but is abundant only in certain parts of this region, where the poisoning mainly occurs.

The chief period of danger is in early spring from April 15 to June 15, more commonly from May 1 to May 15. It is during this period that the death camas, the larkspur the water hemlock and the wild parsnip are most apt to be eaten, as their herbage is then young and tender and there is much evidence to indicate that they are far more poisonous before they come into bloom; the first two fruit and die earlyin July while the others become coarse and unpalatable. This is also during the rainy season, when the ground is soft, and the more poisonous roots of these various plants may occasionally be pulled up, particularly by cattle. Periods of continous rain cause stock to seek shelter, from which they come forth hungry and use less selection in their choice of forage, while they are apt to overeat the wet, rank vegetation and in consequence suffer from bloat and occasional poison. Late snows also cover the more edible grasses and force stock to eat the taller and often poisonous plants, like the large larkspur, the lupine and the water hemlock. Poisoning from loco is also more common during this same period when its conspicuous flowers point it out to lambs and the "loco eaters" and its green, fresh condition makes it more palatable. The lupine on the contrary, is most deadly in July and August, as it matures its seeds and its green herbage renders it conspicuous among the dry vegetation, while it is at this period that sheep are apt to be moved to the mountain and foothill pastures where the lupines are abundant. There are also not-infrequent cases of poisoning in the winter by lupine hay or "slough hay" containing much water hemlock, occasionally even by the dry stalks and seeds of the lupine found on the ranges.

It must also be remembered that stock on their usual pastures and under normal conditions are not apt to be poisoned by these plants, even if abundant, but after times of rain or snow they should be looked after and stock of any kind driven to a new range or when hot and hungry, are apt to eat to excess unpalatable and poisonous plants. Hence in changing ranges or in trailing stock from one locality to another, it is necessary that more care than usual be exercised to prevent them from eating these poisonous plants until they become accustomed to their new conditions.

LOCO.

Oxytropis Lamberti Pursh, or Aragallus spicatus (Hook.) Rydb.

The White Loco Weed is a small pea-like plant, six inches to a foot high, with conspicuous white or cream-colored flowers from a thick woody persistent root, and is fairly well represented in Fig. 1. The "White Loco" is distributed over nearly the whole plains region of the United States from Alberta and Assiniboia south into Mexico, and from Minnesota and Kansas westward to the Rockies. Extensive losses of stock attributed to this species are reported in New Mexico, Colorado and Montana and to a less extent in most of the other states embraced in the region mentioned. In southern California and some other states the loco is attributed to other plants and in particular to two species of Astragalus (A. mollissimus Torr. and A. Hornii Gray) neither of which are native here. In Montana the white loco is found throughout all the eastern plains and is not infrequent in the "mountain meadows" up to 8000 feet altitude. It has not been found west of the Continental Divide, although it occurs on this Divide in the vicinity of Feeley some ten miles south of Butte. To this species (O. Lamberti) must be attributed all or nearly all the cases of loco in this state, as the poisoning occurs only in sections where it is abundant and the other species suspected are too few or too scattered to do much damage. The white loco weed is very unevenly distributed over the section named and appears not to be found in sufficient abundance to be dangerous except in the central "loco zone" extending from Livingston to Billings and from the mountains on the south, northward to the Musselshell, and around the Little Belt and Highwood Mountains. Reports of loco have come from a few other localities in the state, but nowhere else have losses from this cause been heavy and constant. Indeed, in some parts of this "loco zone" the losses sometimes average as high as 50 per cent of the lambs produced and in several localities the sheepmen have been compelled to dispose of their sheep and stock up with cattle. Yet it must not be supposed that the loco is equally and abundantly distributed over all this section. It is found mainly along dry rocky ridges or gravel plains, but exhibits great capacity for growing in nearly every kind of soil. Over much of this area the traveler will look in vain for a single specimen, while in other localities of similar soil, perhaps immediately adjacent, the plains will be white with its conspicuous flowers. This irregularity of distribution may be due in part to the difference in soil, but must be mainly attributed to the fact that it is a relatively recent introduction into the state and that it is spreading from the infected centers. There is considerable evidence to show that the buffalo were the original agents of its introduction, either through having eaten the mature seeds and then scattered them in their offal or from their habit of wal-

Fig. 1. LOCO WEED. Natural Size.

Oxytropis Lamberti **Pursh.** (U. S. Dept. Agriculture.)

lowing in the dust and thus carrying the seeds in their hair for considerable distances through their well known migratory habits. The usual presence of the loco weed in the vicinity of the "buffalo wallows" and its not infrequently abundant distribution in the higher mountain meadows along with abundant signs of the buffalo and in situations, such as the Tobacco Root Range, where sheep or other stock are not tansferred from a loco section, tend to support this theory.

The evidence also seems to show that the loco is slowly spreading from the "loco zone" northward and eastward and that the sheep are now the main instruments of its dispersion and more abundant growth, both by spreading the seeds in their offal and in particular through their tramping in those seeds where already distributed when the ground is soft in the spring. It will also be observed that this "loco zone" is just that part of the state which has longest been given over to the pasturage of sheep.

It has been the general experience of the stockmen in this state that sheep are the chief sufferers from this poison, horses frequently and cattle are rarely affected. It is also a matter of common observation that it is the young sheep and colts that are affected, more frequently yearlings, while the older sheep and horses, grazing along with the others are rarely known to acquire the loco habit. It is also asserted by the stockmen that the animals teach the habit to each other and there is nothing improbable in the statement when we consider their imitative nature, particularly in the matter of grazing.

The loco is a slow poison and appears to affect primarily the nervous system, so that animals addicted to the habit become stupid, wander from the herd, step high, their eyes are glassy, their front teeth grow long and become loose, their coat becomes shaggy and they seek the loco weed and will eat nothing else if it can be obtained. They not only eat the plant itself, but dig for the roots with their hoofs. They appear to have false ideas of form, size and distance and horses in particular when they get hot or exhausted are apt to become frantic, whence the term "loco" or crazy has been applied to the disease. Moreover, the effects are usually lasting and no remedy has yet been found. Horses are permanently injured, as their "crazy" spells disqualifies them for hard work and but few cases of recovery from the effects of the poison have been noted. Sheep left on the ranges where the loco is found become worse and worse, their teeth become black and loose, they eat nothing but loco and they finally die from sheer inability to obtain sufficient food and water to sustain life. Once the habit is fixed, if left on the range they never recover, although they may linger along for several years before death, so that many of the stockmen kill all the animals affected on the approach of winter, rather than to attempt to care for such hopeless cases.

HOW TO PREVENT STOCK FROM BECOMING LOCOED.

A careful study of the subject seems to show that it is the lambs and yearlings that are chiefly affected---old sheep but rarely and then on ranges where the loco is abundant and other forage scant. Also, it is usually colts that acquire the loco habit and the adult horses are much less apt to become addicted to it. This is due to the fact that the loco plant is in full bloom during May and June when the lambs and colts are just learning to graze and the conspicuous white flowers and their sweetish taste serve to attract them, while the intoxicating effects of the poison are more easily fixed in their system. They soon learn to recognize the plant and to seek it for the effects produced, until the desire for the intoxicating poison becomes a fixed habit, in much the same way that the opium or alcohol habit is fixed in man, and the effects are only more rapid because animals know no restraint and the supply of the drug is often unlimited. The loco poison is a true narcotic in its effects and appears to afford certain pleasurable sensations to the animals eating it, so that the desire for the drug finally becomes a passion, and once the taste for the plant is acquired, they will continue to seek it for the effects produced until they are removed from the loco ranges or die from its use.

Several instances have occurred in this "loco zone" where sheepmen have become discouraged on account of the losses from loco, and have sold out their ranches to others, who stocked them again with sheep and suffered little or no loss from loco. In some cases this immunity seems to have been due to the fact that only old sheep were grazed on these loco ranges, in others liberal salting was claimed to have prevented them from acquiring the abnormal taste for the loco weed, but such cases of apparent immunity are exceptional and need more careful study to determine the efficient cause in each instance.

If this theory, that the loco habit is contracted mainly when stock are learning to graze, be correct, then the disease may easily be prevented by grazing lamb-bands on ranges free from loco, at least till after the first of July, when they will have learned their proper forage and the loco will be out of bloom except in the mountain pastures, where no cases of loco poisoning have been reported, and the same is true of the young colts. It is probable that the yearlings affected have acquired the habit during the preceding spring, but in less degree and that it developed mainly during the second season. It will hence be necessary to look after the lambs and colts during the first two of three months after birth, and future care will not be needed.

Sheep taken in the early stages of the disease and placed on good pasturage free from loco, or on alfalfa, frequently take on flesh and are shipped East to be finished for the market, as the quality of the flesh itself is in no wise injured by the loco diet, but animals in ad-

vanced stages of the disease will never recover and may as well be killed for their pelts, as it appears to be the general experience of sheepmen that locoed sheep never produce offspring.

CAN LOCO BE EXTERMINATED?

This question has often been asked and the subject is coming to be of importance, from the fact that many of the stockmen, particularly in the loco zone, are purchasing large holdings and fencing them for their exclusive use, while a number of them have been induced to sell because of the losses from the loco, or have sold their sheep and restocked with cattle, when such changes were entirely unnecessary.

Burning the ranges can do no good, except possibly to destroy some of the seed, as the plant has a deep enduring root from which new plants will arise next spring. Close pasturage in some cases appears to have destroyed the loco in small pastures and on some of the more closely grazed ranges, but there is always some risk that the animals will thus acquire the habit.

At least one state has made a serious attempt to aid the stockman to exterminate the loco. The legislature of Colorado passed a law in 1881 offering a bounty of $21.00 a ton, dry, for "any loco or poison weed dug up not less than three inches below the surface of the ground during the months of May, June and July." This law was repealed in 1885, but cost the state about $40,000 a year during the time it was in force, without any benefits at all commensurate to the expense, as there was no specification as to just what species were included under "loco or poison-weed" and no system employed in eradicating the objectionable plants. Yet, this law seems to have fairly well demonstrated, and indeed was based upon the fact, that loco can be exterminated by digging during the months specified. This seems to be the nearly unanimous opinion of a large number of Colorado stockmen, who have been consulted by this Station.

Now, while it is probably inadvisable for the state to attempt the extermination of loco on the public ranges, it is yet possible and profitable for the stockmen to eradicate it from his own private enclosures and this at relatively small expense, as a recent experiment in Sweet Grass county has demonstrated.

A practical test of the matter in this state was made by Dr. W. A. Tudor of Bozeman on his ranch on the Big Coulee, thirty miles northeast of Big Timber. During the season of 1901 Dr. Tudor lost from poisoning by loco about 300 out of a herd of 2000 lambs. Acting on advice from this station, the next spring (1902) he employed two men for about a month in May and June to dig up the loco plants over an area of about four miles square. The plants were cut off just below the crown—the point where the leaves arise from the root, two or three inches below the surface, a narrow

heavy hoe being used, and wherever this was properly done the plants never sprouted again, nor have new plants come up the present season (1903). No further losses from loco have occurred on his ranch.

From this it appears that the extermination of the loco plant, (Oxytropis Lamberti) is perfectly feasible, even over extensive areas, and the expense of such extermination will hardly exceed 10 per cent of the losses which would otherwise occur during a single year. Yet it is hardly possible to completely exterminate the plant in an affected district with one year's digging, as some plants will be unavoidably missed, while others may spring from seed previously scattered, so that several diggings may be necessary. Loco should always be dug during May and June when in bloom, as its conspicuous flowers serve to point it out and, being dug at this time, prevents it from setting seed.

LUPINE.

There can be no doubt of the poisonous nature of the lupine, although it is certainly one of the best forage plants in the state, if not eaten in its dangerous condition. At least four of the native species have been found poisonous, Lupinus cyaneus Rydb., L. leucophyllus Dougl. (Fig. 2), L. sericeus Pursh and L. pseudoparviflorus Rydb., and it is probable that all are more or less so. These lupines all have blue, pea-like flowers and bean-like pods, whence the name "prairie pea," "prairie bean," "blue bean," etc. The roots are perennial and often somewhat creeping beneath the ground; the stems are two or three feet high with six or eight narrow leaflets arising from a single point on the leaf-stalk. The more dangeroue species of the Upper Yellowstone, (L. cyaneus) grows in dense clumps from a single thick root, often thickly scattered over considerable areas, and appears to be spreading rapidly. L. Cyaneus is found in valleys and along streams and its distribution is almost identical with the so-called "loco zone," fruiting about July 1. The lupines are more abundant in the foothills east of the Divide, but are said to have caused losses in the Deer Lodge valley and in the vicinity of Elliston and the species occur throughout the whole mountainous section of the state. The principal species mentioned bloom early in June and are in fruit some three weeks later. Sheep are the main sufferers although horses appear to be occasionally affected.

In the case of the lupine the conditions of poisoning are peculiar, and most cases of such poisoning seem to be due to transferring

Fig. 2. LUPINE. *Lupinus leucophyllus* Dougl.
½ Natural size. (U. S. Dept. Agriculture.)

sheep to new and unfamiliar ranges where lupine is abundant or to turning them into lupine fields when very hot or hungry or to allowing them to fill up on the wet plants after rains. Sheep on familiar ranges and under ordinary conditions can graze on the lupine with impunity, but in case of long continued rains or late snows, they are apt to eat the lupine to excess and suffer from bloat or poison. There is a general impression that they become immune to the poison by becoming gradually accustomed to it and there is considerable evidence to support this view. Mr. Burke, of Great Falls, reports that sheep fed regularly on hay nearly half lupine were unaffected, while others eating the same hay for the first time died in considerable numbers, and several similar cases have been reported. Several instances have occurred of imported sheep being turned into lupine pastures with fatal results while the native sheep in the same fields were not affected.

Enormous losses, more than a thousand in a number of cases, have been sustained by unloading sheep from the cars in transit upon these lupine ranges when the plants were in fruit. Sheep are often poisoned too by eating lupine hay or hay containing as much as 50 per cent lupine, which has been cut while in seed; yet the same hay fed to cattle has caused no bad effects. There is no doubt of the poison being derived from the fruit, though the wet plants frequently cause fatal bloat. Most if not all cases of poisoning of stock in winter by plants on the ranges are due to lupine.

Stock poisoned by lupine appear to become blind and frenzied; they move off staggering in straight or curved lines and meeting with any obstruction will butt against it with spasmodic leaps, sheep thus frequently pile up against fences or banks and lie till death. There is often more or less frothing and the head is sometimes drawn sideways; they are apt to fall over on their sides and kick aimlessly, but some drop dead without exhibiting previous symptoms. There is little bloat necessarily, although bloat sometimes results from eating the plants, particularly when wet, or eaten to excess, and may accompany the poison or may result fatally without any effects of the poison being shown. The "crazy loco" about Ft. Benton appears to be a form of lupine poisoning.

In the case of the Lupines, as in most other kinds of plant poison, prevention is better than cure and a knowledge of the usual conditions of poisoning will enable the sheepmen and herders to escape most of the losses due to these species. As a general rule **don't turn sheep in on lupine when they are not accustomed to it, or when it is wet or when they are very hungry,** for if they fill up on lupine

alone it is apt to prove indigestible and cause fermentation and bloat, particularly when wet, just as, indeed, will alfalfa or clover, in like condition, while the seeds or beans of the lupine contain an active poison of which it takes much less to fatally affect sheep unaccustomed to them than those that have been eating the seeds regularly. Also in feeding hay containing lupine, at first mix with other hay free from it, afterwards the amount of lupine contained can be gradually increased without any ill effects, but in any case such hay found poisonous to sheep can be fed to cattle without any danger. It is probable that nearly all poisoning from hay in this state arises from the lupine found in it, but several cases have been noted where the water-hemlock was so abundant in hay cut in low ground, as to seriously affect horses fed from it.

Herders and others charged with the care of sheep should not turn hungry sheep upon a lupine range at any time, especially when it is in fruit, and should keep sheep off such ranges when the lupine is wet and should graze them there with care in times of early snows, while in moving sheep from a range free from lupine to another containing it, they should be allowed to graze on the lupine at first but sparingly, but after they become accustomed to it no special care will be necessary even after it is in seed. Knowing thus the conditions of poisoning, it is quite possible to avoid nearly all the losses occasioned by it.

Fig. 3. WATER HEMLOCK. *Cicuta occidentalis* **Greene.**
⅓ Natural size (U. S. Dept. Agriculture.)

WATER HEMLOCK OR WATER PARSNIP.

Cicuta occidentalis Greene.

This plant is allied to the cultivated parsnip and resembles it to some extent. It is often three or four feet high and has a smooth, green, ribbed, hollow stem spreading above and each branch terminating in an umbrella-like expansion of small white flowers (Fig. 3). It arises from a bunch of thick tuber-like roots which contain a yellow gummy secretion and are the chief seat of the poison, although the seeds have been reported to be more or less poisonous as well as the foliage in less degree. This species is frequent throughout the Rocky Mountain region, but other and equally poisonous species replace it in other parts of the United States. In Montana it is found in wet or swampy places along streams and ditches in the mountainous sections of the state, occurring but rarely in the plains eastward. It is often found in considerable patches in open marshy places, but usually occurs scattered sparingly along streams and ditches, by whose waters its seeds are disseminated. The roots of this plant have long been known to be a deadly poison and have been used by the indians for suicide. The roots and foliage are also thought to be more poisonous in early spring than at other seasons and the semi-persistent basal leaves then attract stock seeking everything green and the roots are frequently pulled up or dug up from the soft ground and eaten with fatal results. It is said too that these roots on being tramped and crushed by sheep and other stock seeking water, exude a yellowish gummy liquid, which floats on the water and, being drunk with it, may affect stock fatally. The mature plant is far less poisonous, particularly when dry, yet a number of cases have been reported where stock have been poisoned in winter from eating "slough hay" of which this water hemlock was one of the chief constituents. Cattle and horses are the most frequent sufferers, but sheep also appear to be poisoned occasionally, though some authors report them as immune. This root is not infrequently mistaken for that of the edible "squaw root" (Carum Gairdneri Gray) with often fatal results to whites and Indians alike.

The poison contained in the root is rapid and deadly, death often resulting within a few hours after it is eaten, but where less of the root is taken the animal may linger along for several days or even eventually recover. The principal symptoms are violent convulsions, frothing at the mouth and nose, excessive urination, shallow breathing, coma and death. An examination of the body after death will usually show the lungs congested with blood and the lining membranes of the stomach and intestines more or less decomposed.

It is usually easy to determine this water hemlock poison by

Fig. 4. DEATH CAMAS. *Zygadenus venenosus* Wats.

the fact that few animals get poisoned at a time and then always in low wet places, the victim not being apt to get far from the locality of poisoning. It is not at all difficult to dig up and remove all the plants of this species in pastures and enclosed ranges. The roots are relatively shallow, being rarely over six inches beneath the surface, and can readily be removed with a spade or hoe and then should be carried away, piled in heaps and burned when dry, as to leave them scattered along the streams only makes them more available to stock. A few years ago the water hemlock was thus dug up and removed from the Daly ranch in the Bitter Root valley and since then there seems to have been no trouble from this cause. The usual remedy employed and the one most available and effective seems to be to drench the animals affected with melted lard or bacon grease.

DEATH CAMAS.

Zygadenus venenosus Wats.

The Death Camas, also called Wild Onion, Wild Leek (Alberta), and Crowfoot, is an onion-like plant, arising from a bulb and having narrow leaves and a single stem a foot or so high, with a narrow spike of yellowish white flowers blooming about June 1. (Fig 4). No part of the plant has the smell or taste of the onion and the plants appear singly scattered over the upland swales or valley slopes, where it is often found in the greatest profusion over extensive areas, which are white with its flowers during the period of blooming. It matures its fruit soon after blooming and early in July dies down to the ground again.

This plant is native from Assiniboia and Nebraska westward to the Pacific Coast and is found throughout the entire state of Montana, but is not sufficiently abundant to be dangerous to stock except in the foothills east of the divide and on the high upland benches of the plains. West of the Divide it is scattered sparingly throughout most of the region below 5,000 feet, but I am not aware that it has caused any trouble in this section.

The chief period of danger in the case of death camas is in May and June, when its great abundance over certain "poison zones" and its rank, dark-green leaves frequently cause it to be eaten to excess by the bands of sheep grazed in such sections. The bulb is the most poisonous part of the plant, but the sheep appear to be poisoned mainly by eating an excess of the stems and leaves, as it is difficult to pull up the bulbs even when the ground is soft from rain or melting snow and it is usually the case that several hundred get poisoned at the same time. Sheep after having been grazed several hours on grass are often then grazed over these fields of death camas with impunity. The poisoning usually occurs when the sheep are turned hungry upon these poison belts and allowed to fill up on the death camas before reaching grounds where grass is more abundant.

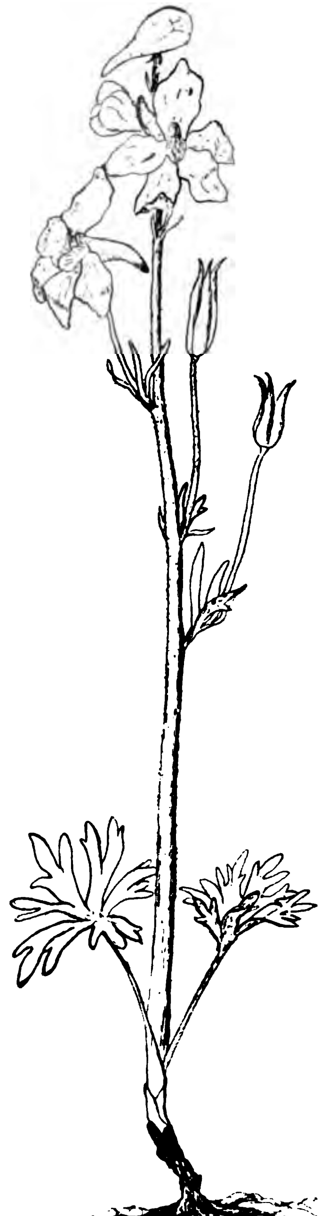

Fig. 5. SMALL LARKSPUR.
Delphinium Menziesii DC.
Half natural size.

Apparently sheep alone are apt to be poisoned by this species. They first become stiff in the legs and have trouble in walking, later exhibit difficulty in breathing, stagger, foam at the mouth and nostrils with a jerking of the head and limbs in intermittent spasms, resulting finally in complete muscular paralysis and death. The poison seems to affect chiefly the voluntary muscles, causing paralysis which finally affects the organs of respiration, causing congestion of the blood in the lungs and death. Lambs are said to be affected by milk of a ewe suffering from the poison. The popular remedy for poisoning by death camas is bleeding in the extremities, usually the mouth or tail and this has often been found effective in the early stages of the poison, but later it is difficult to make the blood flow. The philosophy of this treatment has not been explained by veterinarians, but the remedy seems to be in general use for death camas and larkspur.

To prevent poisoning by death camas it is only necessary that care be taken by the herder not to graze his sheep in the swales and flats where this plant is abundant, particularly during May and early June. The presence of the plant can easily be detected by the darker green foliage of the onion-like leaves, which come up before the grass and its identity can be determined by digging to the bulb, while the prominent white flowers easily distinguish it after it comes into bloom. There is little danger of poisoning by death camas after the middle of June, as the plant dies down to the ground soon after. The localities on the ranges where the plants are found in abundance should be noted and avoided during these two months.

LARKSPUR.

Under the name Larkspur, or Aconite several related plants are designated in Montana. They all have blue or bluish flowers and rounded divided leaves and the poison, the same in all, is located mainly in the root—in fruit and foliage in less degree.

The Little Larkspur, Delphinium Menziesii DC. (Fig. 5), and D. bicolor Nutt., is about a foot high and has bright blue spurred flowers. It comes up in early spring as soon as the snow is off the ground and is found in the foothill uplands in the greatest profusion and along the breaks and hillsides of the plains eastward and over most of the mountainous parts of the state up to 8,000 feet. In many cases it is found in similar situations with the death camas, and blooms and dies about the same time, while its symptoms are so similar that it is often difficult to discriminate between the two. The roots of the first species are tuberous clustered and only a few inches beneath the surface, so that cattle appear to pull them up occasionally after rains when the ground is soft, or, like the sheep, where there is a great abundance of the plants, they appear to eat them to excess

Fig. 6. LARGE LARKSPUR. *Delphinium glaucum* Wats.
Parts ½ natural size. (U. S. Dept. Agriculture.)

and suffer from poison or bloat in consequence. Yet it seems probable that the larkspur frequently suffers for the sins of its companions and that from the similarity of situation and symptoms much of the poisoning attributed to it may be due to the death camas and the wild parsnip.

The Large Larkspur (Delphinium glaucum Wats.) is much less abundant and is distributed over a much narrower range of territory in this state, apparently being found along mountain streams and in mountain meadows from 4,500 to 8,000 feet in the region east of the Divide, where in some places it is relatively frequent and its tall juicy stems and foliage serve to attract stock when driven to these ranges, particularly in times of late snows. This is a tall species three or four feet high, growing along streams and in shady hillside thickets and has light blue or nearly white flowers (Fig. 6), coming into bloom in June, after which there is not much danger of poison from this source. This appears to frequently cause bloat as well as to be a source of poison to cattle, other animals being rarely affected.

Along with these species of larkspur and usually confused with them is the true Aconite (Aconitum Columbianum Nutt.), which is rare in Montana, but is found along streams high up (6,500 to 8,000 feet) in the mountains on the south and west boundary of the state, where stock occasionally get it in passing across the range. This resembles the tall larkspur in size and leaf, but has blue spurless flowers and the foliage is said to be very poisonous.

Larkspur, particularly the large larkspur, is frequently the cause of bloat, and the animals affected may or may not also exhibit symptoms of poison. When the roots are eaten, or even considerable of the stems and foliage, animals exhibit stiffness in their legs and show difficulty in walking; they lag behind and lie down. There is a spasmodic twitching of the muscles of the sides and legs with convulsions in the final stages. As in the case of the death camas, the poison affects mainly the heart and organs of respiration, giving reduced pulse and shallow breathing, ending in convulsions and death. Cattle are mainly affected, sheep more rarely. The popular remedies are bleeding at the extremities, in the mouth or tail, and drenching with melted lard, or when this is not convenient, strips of fat bacon are forced down their throat.

It will usually be found possible to keep stock away from ranges where the small larkspur is so abundant, at least during the early spring when it is dangerous, while in mountain pastures it is feasible to dig up the large larkspur over limited areas, as it nowhere is found in any great abundance like the small species, but stock of all kinds should be looked after during periods of rain or after late snows, when they are more apt to get poisoned.

Fig. 7. WILD PARSNIP. *Pteryxia thapsoides* Nutt.

Half natural size.

WILD PARSNIP OR WILD PARSLEY.

In the spring of the year complaints constantly reach the Station of stock being poisoned on the high ridges and dry upland breaks of the foothill region east of the mountains and to some extent eastward. Investigation has been made of a number of localities of such poisoning and stockmen have been consulted as to the plants suspected and it appears that at least two species of the parsnip family must be held responsible, Leptotaenia multifida Nutt. and Pteryxia thapsoides Nutt., the latter figured in Fig. 7, which may also very well represent the early stages of Leptotaenia. These are found here on dry, rocky ridges and dry hillsides in loose soil. Both species have thick, deeply penetrating roots and send up a cluster of finely divided leaves in early spring before the other plants have come up, so that cattle in particular, are tempted by their green attractive appearance. Yet, it is probable that their chief poison lies in the root, which often projects more or less above the surface so that it can be bitten off. The Leptotaenia usually begins blooming when less than six inches high, but is two or three feet high when in mature fruit. The Pterixia also begins blooming when only a few inches high and grows finally to a foot or more. Both have small yellow flowers and can not be distinguished in their early stages except by the botanist. The evidence of the poisonous nature of these two species, while not conclusive, is so strong that care should be taken to prevent stock from access in early spring to pastures where these plants are found in abundance.

The symptoms of this poison are much the same as those of the water hemlock. There is stiffness of the legs in walking, froth at the mouth, convulsions followed by death, often accompanied with bloat. The exact nature of this poison and accompanying symptoms need further study. These plants can be easily dug up in pastures, and enclosed ranges. Milk is said to be useful as an antidote.

POISONING BY ALKALI.

It is necessary to distinguish this kind of poison from that caused by plants, with which it is often confused. There can hardly be any doubt as to the fatal effects of concentrated alkali water or of alkali salts when taken in excess, particularly by animals coming in from ranges where such salts are not abundant. Stockmen are practically agreed as to the danger from this source and certain "poison ponds" in the eastern part of the state seem to have no other characteristic except that of being surcharged with alkali, but the subject has been but little studied as yet and it is not always possible to distinguish between this and the various plant poisons.

In general the excess of alkali will result in bloat, often followed

by scours and there is usually a well marked froth and a deposit of an alkali-like substance about the mouth and nostrils. Sometimes the effect of such alkali water seems to be to hasten the action of the poison of the death camas in the stomach and the symptoms are then those of the latter, but are not developed before drinking the water and appear to result from it.

This poisoning by alkali is limited to certain localitites in the eastern part of the state, where there is much alkali in the soil and water and the poisoning occurs in the later summer or during winter thaws, when the water collects in the alkali flats and may then be drunk to excess by stock in need of salt.

Salting stock regularly is thought to prevent this trouble and animals when first turned on alkali ranges, should be kept from the more stagnant pools, till they become accustomed to the dilute form of the salts. The remedy is simply to keep them away from such ponds and give them pure water till they recover, or in case of bloat, to treat them for such.

REMEDIES.

As yet, practical methods for treating these different plants poisons have not come into general use and most of the remedies recommended are in their experimental stage. All that will here be attempted will be to enumerate the various remedies proposed or found effective in the given cases.

For bloat in its more dangerous form "sticking" is the usual remedy for sheep and cattle. This is accomplished by plunging a wide-bladed knife directly into the stomach and thus allowing the accumulated gas to escape. The point where the incision is made is on the left side about half way between the hip bone and the ribs and is usually designated by being the point of greatest projection. There is little danger of making any serious mistake and animals thus treated usually recover without further attention. Horses can not be treated by this method. The regular instrument designed for this operation of rumenotomy is the trochar and canula which can be ordered by any druggist and will be found useful in the case of cattle, but sheep are frequently affected in such numbers that the knife is the only resource.

For the various kinds of actual plant poison the remedy generally recommended is permanganate of potassium, which can be purchased at drugstores in the form of reddish-purple crystals which are readily soluble in water and should be thus given. A teaspoonful of the crystals dissolved in water is enough for about 12 sheep or 4 cows. Wilcox recommends giving this with an equal amount of sulphate of aluminum (alum) in order to secure the best results.

This is put up by Dr. Emil Starz, Helena, Mont., in conven-

ient 10-grain tablets under the name of "Ozonine" popularly called "Starz' Tablets," which are highly recommended by those who have used them. Some even report giving them dry to sheep for death camas poison with good results. Dr. Starz also recommends similar tablets composed of potassium permanganate, ammonium chloride and sodium carbonate, which when dissolved in the stomach give off ammonia as a cardiac stimulant. Some stockmen in Meagher county report having used a dilute (125 to 1) form of the sheep-dip "Zenoleum" (Zenner Disinfectant Co., Detroit, Mich.) for bloat and lupine poisoning with fair success, but neither of the remedies have been tried by this Station.

Of the more common remedies employed, melted lard, bacon grease or the bacon itself have been found effective in many cases of larkspur, water hemlock and other poisons, and is worthy of trial for all such poisons except loco. Milk appears to be sometimes used in a similar way. Decoction of tobacco and a solution of alum have been used successfully for lupine and Dr. M. E. Knowles recommends raw linseed oil for lupine and larkspur. Bleeding is practiced extensively for poisoning by death camas or larkspur, and is highly recommended by those that have tried it, but this is of doubtful benefit for water hemlock, wild parsnip or lupine. Just what action the bleeding has, or whether it is of any real benefit, the veterinarians appear doubtful, yet it seems possible that where death results from congestion of the blood about any organ, this congestion may possibly be relieved or prevented from proving fatal by such bleeding. Certain it is that this remedy is frequently practiced in the cases mentioned and with apparently beneficial results. The experimental study of the effects of these plant poisons and their remedies by a competent veterinarian is now imperitatively demanded by the stock interests of the state and, indeed, of the whole West.

The following provisional scheme is offered to determine the plants usually causing any given case of poison.

SYNOPSIS OF POISONS.

CATTLE.

Poisoned in low ground:

Convulsions, frothing, excessive urination; occurring mainly in early spring.................. **Water Hemlock.**

Bloat, scours, alkali froth; occuring in late summer or during winter thaws .... **(Alkali.)**

Poisoned on uplands or along mountain streams:

Bloat or stiffness in legs, twitching of muscles in sides and legs, shallow breathing, convulsions; in April, May or June, ... **Larkspur.**

Poisoned on dry rocky ledges, on high ridges or on dry hillsides:

Bloat, stiffness of legs, convulsions, frothing; in April and May .... **Wild Parsnip.**

HORSES.

Poison slow, rendering them stupid, sight affected, crazy when tired or hot .... **Loco.**

Poison rapid in action:

Blind and frenzied, spasmodic convulsions; July and August or from lupine hay in winter.............. **Lupine.**

Convulsions, frothing, excessive urination, coma; in low ground; April and May.............. **Water Hemlock.**

Bloat, scours, alkali-like froth; in late summer or during winter thaws............................ **(Alkali.)**

SHEEP.

Poison slow, rendering stupid, front teeth long, inclined to wander from herd; lambs and yearlings mainly...... **Loco.**

Poison rapid in action:

Bloat, or blind and frenzied, pile up against obstacles, spasmodic convulsions; in July and August or from lupine hay in winter, or after snow or rain.............. **Lupine.**

Poisoned along streams:

In early spring, or from "slough hay" in winter; convulsions, frothing, excessive urination, coma...... .... **Water Hemlock.**

In late summer or during winter thaws; bloat, scours, alkali-like froth .... **(Alkali.)**

Poisoned in swales, on high benches or in foothill valleys:

Stiffness in legs, convulsions, final paralysis; many affected at once; May and June.............. **Death Camas.**

Poisoned in foothills or along breaks, and mountain streams:

Twitching of muscles in sides and legs, stiffness of gait, occasionally bloat, final convulsions; few poisoned at once; in May and June.......................... **Larkspur.**

Poisoned on high rocky ledges or high dry ridges in early spring.

Bloat, stiffness of legs, convulsions, frothing; few poisoned at once.......................... **Wild Parsnip.**

SUMMARY.

1. More than 90 per cent of all cases of stock-poisoning by plants in Montana can be traced to some six groups of plants---the loco, lupine, water hemlock, death camas, larkspur and wild parsnip, and most of the losses resulting may be avoided by a knowledge of these plants and of the conditions under which such poisoning occurs.

2. The loco habit is usually acquired by lambs and colts in May and June, when the plant is in bloom and they are first learning to graze. Old sheep and horses rarely become locoed, unless range is short and the loco abundant.

3. The loco plant can be exterminated by digging the plants with a hoe while they are in bloom in May and June, cutting the main root below the crown and some two or three inches beneath the surface.

4. Lupine is dangerous if eaten in excess when wet, or when sheep are hot and hungry or when they are not accustomed to it, and it is particularly poisonous when the seeds are mature, if eaten in quantity or by sheep not accustomed to this diet. Cattle appear not to be affected and horses but rarely. Under normal conditions the lupine is an excellent forage plant.

5. Water Hemlock poisons horses and cattle chiefly and may be easily destroyed by digging it up along the streams and ditches. It is most dangerous in early spring.

6. Death Camas causes extensive losses among sheep in the spring in certain "poison zones" in the foothills and on the high benches east of the Divide. Herders should keep their bands away from localities where the plants are abundant, particularly when they are hungry. After July 1 there is little danger as the plants then fruit and die.

7. The Larkspur is found in much the same situations as the death camas and the same rules will apply as for the latter.

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INDEX.

ERRATA:—p. 77, line 18, "3 and 4" should read "4 and 5."
p. 77, line 19, "6" should be "7."

BULLETIN No. 46,

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

TWO INSECT PESTS.

Bozeman, Montana, June, 1903.

REPUBLICAN,
Bozeman, Montana,
1903.

MONTANA AGRICULTURAL

Experiment Station.

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Bozeman, Montana.

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Montana Experiment Station.

BULLETIN NO. 46. - - JUNE, 1903.

TWO INSECT PESTS.

R. A. COOLEY

THE ROSEBUD CURCULIO

Rhynchites bicolor Fab.

The rosebud curculio occurs very commonly on wild and cultivated roses in Montana. The beetles are rather shy when discovered, and though their movements are not quick, they soon disappear under a leaf or stem when a person approaches. In common with many other insects, they have the habit of drawing in their legs when in danger and allowing themselves to drop to the earth, where they remain motionless for a short time, or until the danger has passed. This is doubtless an effective means of protection against natural enemies.

The colors found on the beetle are red and black. The wing covers, which make up the greater part of the upper surface of the body, and the thorax (prothorax) are red, while the head, including the beak or snout, the antennæ, the legs, and the entire under surface of the body are black.

Mr. F. H. Chittenden, an Assistant Entomologist in the United States Department of Agriculture, reports* that in Colorado specimens are found in which the greater part of the head, legs and antennæ are red like the upper surface of the body.

The beak or snout is long and slender, as indicated in the accompanying figure (Fig. 1. a. and d.). The antennæ are club-shaped and are attached near the middle of the snout, one on each side. The mouth parts are situated on the extreme end of the beak, and are made up of a number of pieces, the most formidable of which are the mandibles, which are toothed on both the inner and outer edge. The mouth parts viewed from beneath are illustrated in Figure 1, g. Exclusive of the beak the beetle measures a little less than one-fourth of an inch in length.

The injuries for which the species is responsible are done by the adult or beetle, and so far as is known by the writer, the larva, though it feeds in the fruit of the rose, does no harm to the bushes in any way. The principal injury accomplished by the beetle is done by boring small, deep holes into the buds. Many holes are often bored into a single bud. Though such a bud may open, the resulting rose is of no value. Other buds cease to develop when eaten into and soon wither and dry up. The beetles also bore holes into the stems of the roses at right angles to the axis. Buds affected in this way wilt, and hang from the stems, and later dry.

We have not been able to see any particular significance in the boring of holes into the stems, though when we began the studies it was thought possible that the buds were caused to wilt and dry for the purpose of preparing a suitable food for the young. Though very

* p. 99, Bulletin Division of Entomology. New Series, No. 27, 1901.

many such buds have been broken open and examined, we have never found a larva feeding in one.

Complaints of the injuries caused by this beetle have reached the Experiment Station from various parts of the State, particularly from Kalispell, Missoula and Bozeman. The injuries are scarcely less serious and extensive than those of the rose chafer, (*Macrodactylus*

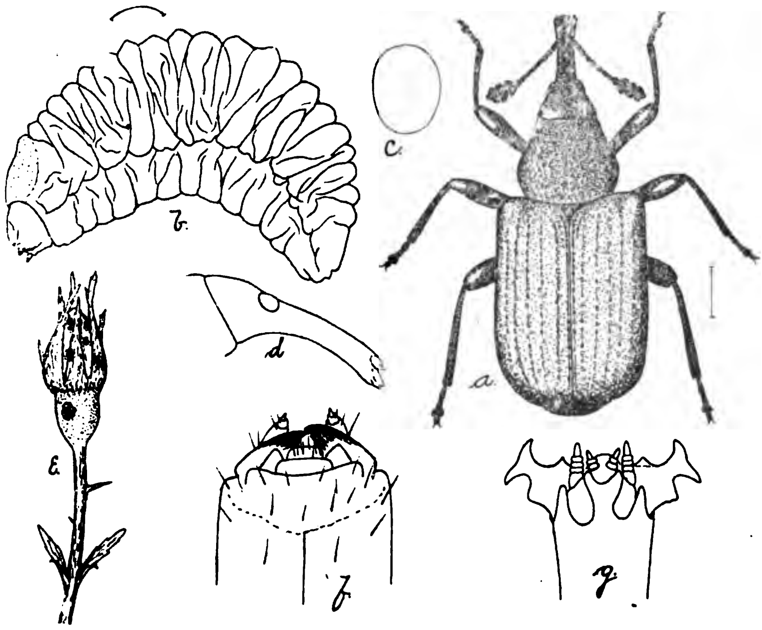

Fig. 1. ROSEBUD CURCULIO—a., adult beetle; b., larva; c., egg; d., sideview of head of beetle; e., bud injured by the beetle; f., mouthparts of the larva; g.. mouthparts of the beetle. (Drawings by the writer.)

subspinosus) in the Eastern States, and a number of cases have come under the writer's attention in which persons have given up an attempt to grow roses on account of the injuries of this insect. We have received no reports of injury by this insect on green-house roses.

The species is a native one and has been found by the writer on wild roses far into the mountains in Montana. Various writers have

reported it as a troublesome pest on roses in widely separated parts of the United States. It occurs in the northern tier of States from ocean to ocean and as far south as Mexico.

Mr. Alexander Craw, Quarantine Officer and Entomologist of the California State Board of Horticulture, has mentioned this species as being frequently found eating into ripe blackberries and raspberries which it causes to decay.

The beetles appear on the bushes early in June and continue until the latter part of August. The eggs are deposited in various places. Most of those found by the writer were in the buds, either in the unexpanded petals or in the young fruit. One egg was found in the tender extremity of a new cane and one in a Cynipid gall. In all cases the eggs were found in the holes made with the beak, and were placed well down in the holes, below the surface. The form of the eggs is shown at c, Fig. 1. They are semi-transparent and almost colorless.

The eggs hatch in a few days, probably about a week or ten days. We have never been able to find larvæ except in the rose hip or fruit, and this is doubtless the normal place for their development.

They feed upon the seeds which fill the greater part of the cavity of the fruit. The fleshy coating of the fruit is not eaten so far as we have observed. Examination of a fruit containing a nearly full grown larva shows a part or all of the seeds excavated to mere shells and the body of the larva buried in a mass of waste and excrement. Such a fruit shows a blackened scar on the side which marks the spot where the parent beetle bored in to deposit the egg.

The larva or grub (Fig. 1, b.) is yellowish white with a rosy tint and instead of being straight has the back arched. It has no legs. The head and mouth parts viewed from above are shown at Fig. 1, f.

We have never found the larvæ in abundance. A large bush bearing many hips seldom has more than two infested fruits, though

many may have the external mark that would indicate them to be infested.

The grubs finish feeding and disappear early in October. We have never found the larvæ or pupæ in winter quarters and are not informed as to how they pass the winter. We examined many rose hips that have been occupied by larvæ and found exit openings in the side of the fruit, and the grubs gone. This would seem to indicate that, when full grown, the larvæ eat holes to the surface and go to the ground to pupate and pass the winter.

In the Bitter Root valley and at Bozeman the writer has repeatedly found the larva of a moth tunnelling in the new canes of wild roses, and at Missoula and Hamilton we have had complaints of what appears to be the same insect on cultivated varieties. The larva begins at the tender extremity of the shoot and bores downward in the center of the stem, thereby killing it and seriously interfering with the normal development of the bush. This insect should not be confused with the rosebud curculio.

REMEDIES.

In many cases hand picking is all that is necessary to get relief from the injuries caused by this insect.

In a previous paragraph we have mentioned the fact that when disturbed the beetles drop to the ground. Taking advantage of this one can catch the beetles by holding a hand, or better, a pan containing kerosene underneath and causing the beetles to drop.

Under some conditions hand picking is a futile measure. When the cultivated roses to be protected are in the vicinity of wild roses which breed the beetles year after year, it will probably be useless to attempt hand picking. Under some circumstances it may be profitable to destroy wild roses that furnish a breeding place. In general, however, it should be borne in mind that the beetles fly over a considerable distance and that until fence corners and waste lands of the

surrounding country are cleaned of the native roses, more or less trouble will always be experienced.

It is said that a spray of Paris green will kill the beetles.

THE POPLAR LEAF-FOLDING SAWFLY.

Pontania bozemani Cooley.

The various native and introduced poplars easily take first place as shade and ornamental trees for Montana, and they far outnumber all other kinds now in use in the State. The leaf-folding sawfly is one of the most troublesome and widespread of the many species of insects that feed upon these shade trees. For the past few years this insect has been steadily increasing in numbers and duriug the summer of 1902 was very commonly seen. In a few cases trees were found with neariy every leaf deformed, and in the residental parts of some of the towns and cities of the State it has been so abundant as to very greatly injure the natural beauty of the trees.

This insect appears to be native to the State and occurs in natural growth along streams as well as in trees used for shade.

A close study of adult spacimens showed them to belong to an undescribed species, and we have therefore proposed the name PONTANIA BOZEMANI, after the city in which it first came under our notice. The writer's technical descriptions establishing the species are to be found in the current volume of the "Canadian Entomologist."

This insect makes its presence conspicuous by the manner in which it deforms the leaves. Affected leaves have their lateral edges turned under until they lie against the lower surface. See Fig. 2, g.

Both edges of the same leaf are often folded. The cavity formed by the fold is occupied by the larva.

The presence of the insect is objectionable not for any real injury that is done to the health of the tree but because of the disfigurement to the foliage.

The adult hibernates among the leaves on the ground, and, emerging in the month of May, lays its eggs on the young leaves that are just being put forth. The new shoots of the poplars continue to grow through the summer months, and as they increase in length new leaves appear. The sawflies continue on the foliage depositing their eggs through the month of July.

Although the writer has often examined the eggs in their minute pockets under the epidermis in the folds of the leaves, the insect was not seen in the act of depositing them until July 1, 1902, when the whole process was seen and recorded. While searching the cottonwoods on the college campus for evidence in the life-history of the insect, a female was seen going from leaf to leaf as if prompted by some distinct purpose. Different leaves were carefully examined by the sawfly and finally one was selected. The young, tender leaves of poplars, previous to being expanded, have both the lateral edges rolled upward and inward parallel with the midrib (involute), and it is on top of this roll, and hence on what is to become the under surface of the leaf, that the sawfly works. Having selected the leaf the sawfly we observed began at the end of the roll nearer the top of the leaf and walked slowly along to the other end repeatedly puncturing the tender leaf with the ovipositor. When at the other end of the roll, she stopped and, without turning around, went through motions which indicated that she was laying an egg in the leaf. underneath her body, far up toward her head. A slight breeze was blowing and causing the foliage to move so the writer was able to take the stem in his hand and follow the whole operation closely without frightening the sawfly away. The ovipositor could be distinctly seen both while making the numerous punctures in the leaf and while depositing the egg. After the sawfly had left. the leaf was carefully examined with a hand lens and although

almost the exact spot was known the egg pocket could not be found. The leaf was marked with a piece of white thread and going back later in the day the egg-pocket and egg were distinctly seen. The exact duration of the egg stage was not determined on account of absence from the college but was very close to nine days. Long before the egg hatched the leaf-fold was completed, thus making it clear that the adult insect was wholly responsible for the folding of the leaf.

The egg of this insect is long-ovate, about one-twenty-fifth of an inch (1.05 mm) in length and whitish in color. The egg (shown in

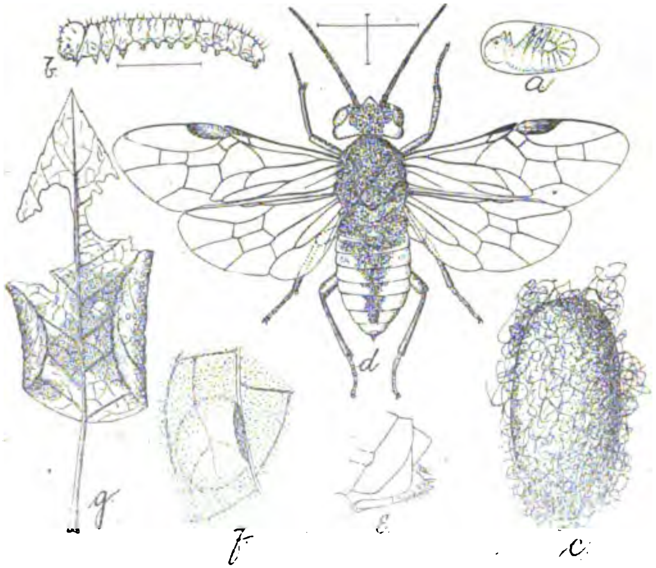

Fig. 2, LEAF FOLDING SAWFLY—a., egg showing embryo; b., immature larva; c., cocoon; d., female sawfly; e., sideview of extremity of abdomen of female; f., portion of poplar leaf showing the egg pocket under the epidermis; g., leaf with the two edges folded under and other parts eaten away. (Author's illustration, first used in the Canadian Entomologist.)

Fig. 2 a.) had been kept in formalin for a few month and showed the nearly mature embryo as indicated in outline in the drawing. The young larva is at first very delicate and almost colorless, but later, as it grows larger, it becomes stronger and turns to a pale green color.

See Fig. 2, b. During its early life the larva feeds wholly from the inner surface of the portion of the leaf that is folded and forms its retreat, and this part soon becomes more or less skeletonized. When it has reached a greater size making more food necessary, instead of continuing to eat away the walls of its home, it ventures forth out of the end of the fold opposite from the petiole and eats holes through the leaf not stopping with the surface parts. The part of the leaf making up the fold and adjacent parts become blackened. The fold of the leaf is used as a hiding place throughout the larval life.

A very large proportion of the larvæ never reach sufficient size to begin feeding outside the fold of the leaf, though certain letters of inquiry about this insect from citizens of the State would seem to indicate that at times practically all come to maturity. In such cases serious injury to the foliage would follow.

During the first two years that the writer had this insect under observation, not a leaf was found that contained a larva more than a few days old In fact, the usual injury throughout the State is only the folding of the leaves. We have found nothing to indicate the cause of the death of this large proportion of the larvæ. The vacated cavities later become inhabited by plant lice and various other insects and spiders.

A leaf folded by this insect and partly eaten is shown at g. in the accompanying figure.

When fully grown the larva constructs a cocoon in the fold of the leaf. This cocoon (Fig. 2, c.) is ellipsoidal in form, 8.- mm long and brown in color. The cocoon drops to the ground along with the leaf and is occupied by the insect until the following spring. The adult insect emerges from the cocoon in the spring and lays the eggs as already described.

The female adult insect (Fig. 2, d.) is a "four-winged fly" one-sixth of an inch (6.-mm) in length and resinous-yellow and black in color. The antennæ, a large spot on the upper side of the head, the

upper side of the thorax and a tapering stripe on the upper side of the abdomen, are glossy black while the remaining parts are, for the most part, resinous yellow. The male insect is slightly smaller, with a more slender body, and has the entire upper surface of the abdomen black.

The leaf-folding sawfly here discussed is a member of a large and important family of insects popularly called sawflies and scientifically known as the TENTHREDINIDÆ. About 2,000 species of sawflies are known.

Though we speak of these insects as "flies" or "sawflies," it should be understood that they do not belong to the true flies or DIPTERA to which order the common house-fly belongs. The sawflies have mouth parts for biting and chewing and are provided with two pairs of wings, while the true flies have mouth parts for lapping, or piercing and sucking, and have only one pair of wings.

Sawflies take their common name from the fact that the ovipositor of the female is so constructed as to resemble a saw. When not in use, the saw, or saws (for there are two of them), are enclosed in a sheath which in turn is situated in a longitudinal groove in the under side of the abdomen at the posterior end. The female uses this ovipositor to cut a slit or pocket in the soft tissues of plants in which to deposit the eggs. In the species now under discussion, and in many others, also, the egg is deposited just under the epidermis of the leaves which is very skillfully separated from the underlying tissues with the ovipositor.

Most sawfly larvæ so closely resemble caterpillars of moths and butterflies as to be easily mistaken for them. They may be distinguished, however, by the larger number of abdominal legs. Sawfly larvæ have from six to eight pairs while caterpillars usually have five or less.

The larvæ of most of the species of the genus PONTANIA, to which the poplar leaf-folding sawfly belongs, feed in abnormal growths called galls on the leaves. The only exception outside of the present species,

known to the writer, is one which rolls the tips of willow leaves and constructs imperfect galls. This species was described from New York City by Mr. C. L. Marlatt of the United States Department of Agriculture.

REMEDIES.

As has been stated, this insect is native to the State and occurs commonly on the natural growth. This fact should be borne in mind in attempting to control it on trees planted for shade or ornamental purposes. When the trees are in the vicinity of natural growth that is infested, it will probably be impracticable to get the protection desired. It should be noted also that the only way to prevent the folding of the edges of the leaves is to destroy the adults before they sting the leaves. The spraying that is suggested below will be of service only in killing the larvæ and, therefore, in preventing the injury to the foliage the following season.

Probably the most satisfactory results will be secured by gathering and burning the leaves in the fall of the year. As we have previously stated, the insect passes the winter among these leaves; hence the utility of destroying the leaves.

Spraying the trees once or twice in July and August with Paris green or arsenate of lead would be useful in killing the larvæ that come out of the folds to feed. It is not necessary to get the poison inside the folds for those that would come to maturity come out of the folds to feed.

BULLETIN NO. 47.

MONTANA

AGRICULTURAL

EXPERIMENT STATION

--OF--

THE AGRICULTURAL COLLEGE

--OF--

MONTANA.

SHEEP FEEDING.

WINTER OF 1902-1903.

BOZEMAN, MONTANA, SEPTEMBER, 1903.

BOZEMAN CHRONICLE--1903.

MONTANA AGRICULTURAL
EXPERIMENT STATION.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

EXPERIMENT IN SHEEP FEEDING, 1903.

F. B. LINFIELD.

CONTENTS.

SHEEP FEEDING.

INTRODUCTION.

Montana is the banner sheep state of the Union with 5,000,-000 sheep owned within her border. The number of sheep have increased rapidly in the past ten years, due to the excellent grass on the range and the substantial profit in the business. From observation and information gathered, the limit of increase, as far as the range is concerned, is very nearly reached. Thus a much larger number of the increase of the flocks will have to be marketed yearly.

This condition will probably call for some change of method in the handling and management of the range flocks. If carefully entered upon, it also means the establishment of large and profitable feeding operations in the state. Because of the excellent herding qualities and closeness of wool, the Merinos will always predominate in the range flocks. The market, however, demands a mutton type.

It is believed that both these demands may be met by the range herder. In those districts that cater to the feeding demand, the range flocks should be largely a ewe flock, strong, vigorous ewes, of the type that would result from using a Rambouillet or Delaine ram. All ewes added to the flock should be of this style and breeding. Such a flock of ewes bred to a good, pure-bred mutton type of ram, would give an excellent feeding lamb. The plan of breeding outlined may not be wholly feasible to the small range holder, but would be entirely so for the larger holder. It may even be profitable to produce the kind of ewe needed by the man who is catering to the feeding trade.

The feeding of sheep for the market has increased rapidly the past few years. This is as it should be, as with a large number of sheep being produced and going into the market and with abundant and cheap fodders, there is every reason why the people of Montana should retain in the state the profits of the feeder as well as those of the grower. Looked at in this light, it will be seen that the interests of the range producer and farm feeder are mutual and reciprocal and not antagonistic as many have thought in the past.

Recognizing the trend of affairs, the Experiment Station some four years ago started experiments to test the value of local feeds in fattening sheep and to learn something of the effect of the local conditions, climate and market facilities upon the financial results of the feeding operation. The results of previous tests are recorded in bulletins No. 21, 27, 31 and 35 and summarized in bulletin No. 39.

The past winter another series of tests were made to gather additional information on this subject, and a report of this work is here given.

During the latter part of the month of October, 1902, a bunch of 110 lambs and 112 two-year-old wethers were purchased from John Robinson of Bozeman. They were selected from a flock of 2,000 purchased by Mr. Robinson for his own feeding. An even lot was selected, but from weights furnished by Mr. Robinson it is believed they were a very close average of the flock. We are indebted to Mr. Robinson for the privilege of making this selection. The sheep arrived at the College farm on Oct. 22d. This was before the writer arrived to take charge of the work of the department, and, unfortunately, the sheep were not weighed at this time. From this date until November 18, the sheep were allowed the run of the Station farm to gather what they could from the stubble and hay fields. They made substantial gains during this period, but not being weighed when they arrived, the exact gain cannot be determined. From the fields the sheep came into the feeding lot in excellent condition, a very desirable point in successful feeding.

The lambs showed strong evidence of "Down" blood, many of them with dark faces and legs. The wethers were also close

fleeced, but there was not as large a proportion of dark faces. They were selected from a range flock that had evidently been graded up strongly with Shropshire blood. The lambs cost at the Station farm $1.80 each, the wethers $2.80 each.

THE PLAN OF THE EXPERIMENT.

In connection with the main thought, the feeding and finishing of sheep for market, some comparisons were made as to the relative food value of different kinds of grain. The lambs and wethers, therefore, were divided into five lots each, 22 lambs in each lot of lambs and 22 wethers in three lots and 23 in two lots.

The lots were as follows:

Lambs. Lot 1, fed clover and wheat screenings.
" Lot 2, fed clover and wheat.
" Lot 3, fed clover and oats.
" Lot 4, fed clover and barley.
" Lot 5, fed clover and wheat, oats and barley mixed in equal quantities by weight.

The wethers were also divided into five lots and fed the same kind of rations as the lambs.

The clover was fed *ad libitum* and what waste was left over, was weighed back twice a week. The grain was started at 5 pounds per day for each lot some ten days after the feeding test was started. The grain ration was gradually increased, one month being taken to get up to a full grain ration of 1 pound of grain per day per lamb or wether. Both grain and hay were fed twice in the day, morning and evening.

KIND OF FEED AND PRICES.

The hay was a mixture of medium and alsike clover of medium quality. Some of it was stacked a little green and was slightly musty. It was eaten readily by the sheep.

The wheat screenings consisted of small and broken wheat together with other grain and the small seeds usually associated with it; in other words the best grade of screenings.

The wheat, oats and barley fed was good, marketable grain. All the grain was fed whole. The grain and hay were weighed for each lot at each time fed.

The prices on the feed were as follows, being market prices at the beginning of the experiment. Prices, of course, vary from year to year, but they are given to afford a comparison on this basis.

Clover hay	$5.00 per ton
Wheat screenings	75c per 100 lbs.
Wheat	88c per 100 lbs.
Oats	85c per 100 lbs.
Barley	95c per 100 lbs.

The sheep had access to the water from a small stream which ran through the lower part of the yards.

The yards in which the sheep were fed were about 8 feet wide by 100 feet long and a straw-covered shed at one end provided shelter. It was noticed, however, that they seldom used this shelter except in very stormy weather.

WEIGHING SHEEP.

The sheep were weighed on two days at the beginning of the test, and the average of this weight taken as the beginnnig weight. They were weighed every two weeks after this date, the weighings being made with one day intervening and these two weights averaged. The sheep were weighed right after noon, or mid-way between the morning and evening feed.

TABLE I.—Weights and Gains of Wethers.

Period.	Lot	How Lots Were Fed.	No. of Wethers.	Weight at Beginning of Period.	Weight at End of Period.	Gain in Live Weight.	Average Gain Per Day Per Lot.	Average Gain Per Day Per Wether.	Average Weekly Gain Per Wether.	Average Gain for Each Wether.
				Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
First Period 31 Days Nov. 22 to Dec. 23.	1	Wheat screenings and clover hay	22	2717½	2937½	220	7.09	.322	.....	10.00
	2	Wheat and clover hay.	22	2725	2940	215	6.93	.315	.....	9.772
	3	Oats and clover hay...	22	2795	3020	225	7.25	.329	.....	10.227
	4	Barley and clover hay.	23	2745	2992½	247½	7.98	.347	.....	10.761
	5	Mixed grain, clover...	23	2832½	3052½	220	7.09	.305	.....	9.565
Second Period 28 Days Dec. 24 to Jan. 20.	1	Wheat screenings and clover hay	22	2937½	3042½	105	3.75	.174	.....	4.772
	2	Wheat and clover hay.	22	2940	3040	100	3.57	.172	.....	4.545
	3	Oats and clover hay...	22	3020	3115	95	3.38	.153	.....	4.318
	4	Barley and clover hay.	23	2992½	3135	132½	4.71	.204	.....	5.761
	5	Mixed grain, clover...	23	3052½	3120	67½	2.41	.104	.....	2.935
Third Period 36 Days Jan. 21 to Feb. 25.	1	Wheat screenings and clover hay	22	3042½	3180	137½	3.81	.173	.....	6.250
	2	Wheat and clover hay.	22	3040	3232½	192½	5.34	.242	.....	8.750
	3	Oats and clover hay...	22	3115	3320	205	6.69	.258	.....	9.318
	4	Barley and clover hay.	23	3135	3372½	237½	6.56	.285	.....	10.327
	5	Mixed grain, clover...	23	3120	3247½	127½	3.54	.153	.....	5.543
Whole Time 95 Days.	1	Wheat screenings and clover hay	22	2717½	3180	462½	4.87	.221	1.55	21.02
	2	Wheat and clover hay.	22	2725	3232½	507½	5.34	.243	1.70	23.07
	3	Oats and clover hay...	22	2795	3320	525	5.52	.251	1.76	23.86
	4	Barley and clover hay.	23	2745	3372½	627½	6.60	.287	2.01	27.29
	5	Mixed grain, clover...	23	2832½	3247½	415½	4.37	.190	1.33	18.04
Average and total for all lots.			112	13814½	16352½	2538	26.71	....	....	.....
Average for one wether			...	123½	146	....	.....	.238	1.67	22.66

TABLE II.—Food Eaten and Cost of Food for Wethers.

Period.	Lot	How Fed.		Food Eaten. Clover Fed.	Clover Waste.	Clover Eaten.	Grain	Food Eaten Per Day by Each Wether. Clover.	Grain.	Food Eaten for One Pound Gain. Clover.	Grain.	Cost Per Wether Per Day.	Cost of One Pound Gain.
				Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cents.	Cents.
First Nov. 22 to Dec 23 31 Days	1	Wheat screenings and clover hay	22	2645	175	2470	281	3.62	.41	11.23	1.28	1.21	3.76
	2	Wheat and clover hay	22	2645	220	2425	281	3.55	.41	11.28	1.31	1.24	3.97
	3	Oats and clover hay	22	2645	170	2475	281	3.63	.41	11.00	1.25	1.25	3.81
	4	Barley and clover hay	23	2645	210	2435	283	3.41	.41	9.84	1.14	1.24	3.54
	5	Mixed grain and clover	23	2640	425	2215	283	3.11	.41	10.07	1.29	1.14	3.66
Second Dec 24 to Jan. 20 28 Days.	1	Wheat screenings and clover hay	22	2465	425	2040	616	3.31	1.00	19.43	5.87	1.58	9.26
	3	Wheat and clover hay	22	2460	450	2010	616	3.26	1.00	20.10	6.16	1.69	8.54
	3	Oats and clover hay	22	2455	330	2125	616	3.45	1.00	22.37	6.48	1.71	11.10
	4	Barley and clover hay	23	2455	485	1970	644	3.01	1.00	14.79	4.86	1.7	8.31
	5	Mixed grain and clover	23	2445	560	1885	644	2.88	1.00	27.92	9.54	1.61	15.49
Third Jan 21 to Feb. 25 36 Days.	1	Wheat screenings and clover hay	22	3115	700	2415	792	3.05	1.00	17.56	5.76	1.51	6.61
	2	Wheat and clover hay	22	3115	630	2485	792	3.14	1.00	12.91	4.11	1.66	8.84
	3	Oats and clover hay	22	3115	615	2500	792	3.15	1.00	12.19	3.37	1.63	5.91
	4	Barley and clover hay	23	3115	680	2435	828	2.94	1.00	10.25	3.49	1.69	5.87
	5	Mixed grain and clover	23	3115	755	2360	828	2.85	1.00	18 51	6.47	1.6	10.42
Whole Time 95 Days.	1	Wheat screenings and clover hay	22	8225	1300	6925	1689	3.31	.81	14.97	3.65	1.43	6.48
	2	Wheat and clover hay	22	8220	1300	6920	1689	3.31	.81	13.63	3.31	1.54	6.22
	3	Oats and clover hay	22	8215	1115	7100	1689	3.40	.81	13.52	3.21	1.54	6.10
	4	Barley and clover hay	23	8215	1375	6840	1755	3.13	.80	11.90	2.79	1.54	5.37
	5	Mixed grain and clover	23	8200	1740	6460	1755	2.96	.80	15.55	4.22	1.45	7.65
Average for all lots			112	41075	6830	34345	8577	3.22	.806	13.49	3.38	1.50	6.30

DISCUSSION OF RESULTS.

WEIGHT OF WETHERS.

Table No. 1 gives the weights and gains of each lot of wethers for each of three periods and for the whole time of the test, 95 days. The table shows that the most rapid gains were made during the earlier and later periods of the test, the first month of the feeding test and the last month.

Comparing the different rations, the barley seemed to give the most rapid gains throughout all the periods. For the whole time of feeding each wether in this lot gained 27.29 pounds each. The lot fed oats and clover gained 23.86 pounds for each wether. The lot fed wheat and clover gained 23.07 pounds each or about three-quartres of a pound less than the lot fed oats. Wheat screenings gave a gain of 21.02 pounds and the mixed grain ration a gain of 18.04 pounds for each wether for the 95 days.

The average of the whole flock of 112 head shows that the wethers weighed 123⅓ pounds at the beginning of the test, they weighed 146 pounds at its close, this gaining on the average 22⅔ pounds each.

The table shows the daily gain for each lot, and for each wether, and also the weekly gain for each wether, both by periods and for the whole time of the experiment.

AMOUNT OF FOOD EATEN BY WETHERS.

Table No. 2 gives the amount of food eaten by the wethers and also the cost of the food. The results in this table are also given by periods and for the whole time of the feeding test.

The amount of food eaten per day shows that for the first period a larger proportion of clover was eaten than for the next two periods, but this was to be expected from the smaller grain ration. For the second and third periods, about three pounds of hay per day on the average were eaten. The average for the 95 days shows about 3¼ pounds of hay eaten per day and about eight-tenths pounds of grain. Comparing the different rations,

the wethers fed oats ate slightly the most and those fed the mixture of grain the least clover per day.

FOOD EATEN FOR EACH POUND OF GAIN BY WETHERS.

The pounds of food required for each pound of gain in live weight, is the most valuable test of the efficiency of a ratio. On the average of all the lots it required close to 13½ pounds of clover and 3⅓ pounds of grain to produce 1 pound of gain in live weight. The lot fed on barley required the least food for each pound of gain, viz.: 10.9 pounds of clover and 2.79 pounds of grain. Oats, wheat, screenings and the mixed grain rations follow in the order named. It will be noted that less food was required for 1 pound of gain during the first period than at any later time, though the grain ration was smallest at that period. This may be explained by the general experience that less food is required in the earlier than in the late periods of fattening.

COST OF FOOD EATEN BY WETHERS.

The cost of a ration is not always a safe basis of comparison, as prices vary from year to year and in different localities. The amount of food for each pound of gain is always a safe basis, and thus each person can calculate for himself the cost of feeding in his particular locality. On the basis given in this bulletin, it cost on the average 6.3c for each pound of gain made by the wethers. The cheapest gains were those made on the ration of barley, viz.: 5.37c per pound. Next came oats, costing 6.1c, wheat 6.22c, screenings 6.48c and the mixed grain 7.65c for each pound of gain. It will be noted that the arrangement of the lots on the basis of the *amount of food for each pound of gain* was the same as given for the cost of the feeding.

TABLE III.—Weight and Gains of Lambs.

Period.	Lot	How Lots Were Fed.	No. of Lambs.	Weight at Beginning of Period.	Weight at End of Period.	Gain in Live Weight.	Average Gain Per Day Per Lot.	Average Gain Per Day Per Lamb.	Average Weekly Gain Per Lamb.	Average Gain for Each Lamb.
				Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
First Period 31 Days Nov. 22 to Dec. 23.	1	Wheat screenings and clover hay............	22	1465	1680	215	6.93	.315	.....	9.765
	2	Wheat and clover hay.	22	1555	1747½	192½	6.85	.311	.....	8.75
	3	Oats and clover hay...	22	1555	1735	220	7.09	.32	.....	10.00
	4	Barley and clover hay.	22	1597½	1785	212½	6.86	.312	.....	9.61
	5	Mixed grain, clover...	22	1525	1735	210	6.77	.307	.....	9.54
Second Period 28 Days Dec. 24 to Jan. 20.	1	Wheat screenings and clover hay............	22	1680	1887½	207½	4.73	.215	.....	9.43
	2	Wheat and clover hay.	22	1747½	1915	167½	5.98	.272	.....	7.60
	3	Oats and clover hay...	22	1735	1820	85	3.03	.138	.....	3.86
	4	Barley and clover hay.	22	1785	1945	160	5.71	.259	.....	7.27
	5	Mixed grain, clover...	22	1735	1857½	122½	4.37	.198	.....	5.57
Third Period 36 Days Jan. 21 to Feb. 25.	1	Wheat screenings and clover hay............	21*	1812½	1977½	165	4.58	.218	.....	7.857
	2	Wheat and clover hay	22	1915	2112½	197½	5.48	.249	.....	8.977
	3	Oats and clover hay...	22	1820	2015	195	5.41	.245	.....	8.863
	4	Barley and clover hay.	22	1945	2132½	187½	5.21	.237	.....	8.52
	5	Mixed grain, clover...	22	1857½	2122½	265	7.36	.334	.....	12.04
Whole Time 95 Days.	1	Wheat screenings and clover hay............	21*	1405*	1977½	572½	6.027	.287	2.01	27.24
	2	Wheat and clover hay.	22	1555	2112½	557½	5.87	.267	1.97	25.34
	3	Oats and clover hay...	22	1555	2015	460	4.84	.220	1.54	20.91
	4	Barley and clover hay	22	1597½	2132½	535	5.63	.255	1.88	24.34
	5	Mixed grain, clover...	28	1525	2122½	597½	6.29	.286	2.00	27.16
Total and average for all lots............			109	7637½	10360	2722½	28.65	.....	.....	.....
Average for one lamb....................			....	70	95	......	.....	.263	1.84	25.0

*NOTE—The lamb that died weighed 75 pounds. Had he gained in proportion to the others he would have weighed 60 pounds at start of test, and this amount is deducted from the beginning weight of this lot.

TABLE IV.—Food Eaten and Cost of Food for Lambs.

Period.	Lot	How Fed.	Food Eaten.				Food Eaten Per Day by Each Lamb.		Food Eaten for One Pound Gain.		Cost Per Lamb Per Day.	Cost of One Pound Gain
			Clover Fed.	Clover Waste.	Clover Eaten.	Grain.	Clover.	Grain.	Clover.	Grain.		
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs	Lbs,	Cents.	Cents
First Period Nov. 22 to Dec. 23 31 Days.	1	Wheat screenings and clover hay	1820	265	1555	281	2.28	.41	7.27	1.3	.87	2.79
	2	Wheat and clover hay	1820	240	1580	281	2.32	.41	7.47	1.32	.95	2.02
	3	Oats and clover hay	1820	175	1645	281	2.41	.41	7.53	1.27	.95	2.86
	4	Barley and clover hay	1820	230	1590	281	2.33	.41	7.5	1.34	1.07	3.14
	5	Mixed grain and clover hay	1815	265	1550	281	2.27	.41	7.39	1.33	.93	4.03
Second Period Dec. 24 to Jan. 20 28 Days.	1	Wheat screenings and clover hay	1690	520	1170	616	1.90	1.00	8.83	4.69	1.42	5.74
	2	Wheat and clover hay	1690	465	1225	616	1.99	1.00	7.31	3 67	1.37	5.22
	3	Oats and clover hay	1690	425	1265	616	2.05	1.00	14.85	7.23	1.36	9.85
	4	Barley and clover hay	1690	415	1275	616	2.07	1.00	7.95	3.85	1.46	5.64
	5	Mixed grain and clover hay	1690	535	1155	616	1.88	1.00	9.49	5.05	1.56	6.88
Third Period Jan. 21 to Feb 25 36 Days.	1	Wheat screenings and clover hay	2095	655	1440	775	1.91	1.00	8.76	4.58	1.22	5.62
	2	Wheat and clover hay	2130	660	1470	792	1.86	1.00	7.14	4.01	1.31	5.32
	3	Oats and clover hay	2130	566	1570	792	1.98	1.00	8.08	4.08	1.34	5.48
	4	Barley and clover hay	2130	615	1515	792	1.91	1.00	8.05	4.21	1.42	6.01
	5	Mixed grain and clover hay	2130	630	1500	792	1.98	1.00	5.92	2.99	1.38	3.15
Whole Time 95 Days.	1	Wheat screenings and clover hay	5605	1440	4165	1672	2.02	.81	7.73	2.82	1.11	4.04
	2	Wheat and clover hay	5640	1365	4275	1689	2.04	.81	7.64	3.02	1.22	4.56
	3	Oats and clover hay	5640	1160	4480	1689	2.11	.81	9.59	3.66	1.21	5.50
	4	Barley and clover hay	5640	1260	4380	1689	2.09	.81	8.19	3.16	1.29	5.05
	5	Mixed grain and clover hay	5635	1430	4205	1689	2.01	.81	7.02	2.87	1.22	4.31
Average and totals for all the lots			28160	6655	21505	8428	2.05	.81	8.03	3.11	1.21	4.49

WEIGHT OF LAMBS.

Table 3 shows the weights and gains of lambs, by periods and for each lot. The lambs averaged 70 pounds at the beginning of the test and 95 pounds at its close, thus gaining 25 pounds in 95 days.

Lot 1, fed on screenings, made the largest gain, viz.: 27.24 pounds, followed by the lot fed on mixed grain, 27.14 pounds, the wheat fed lot gained 25⅓ pounds, the barley fed lot gained 24⅓ pounds and the oats fed lot gained 20.9 pounds. The lowest *daily* gain was made by the lot fed oats, each lamb gaining but .22 of a pound. The highest daily gain was by the lot fed screenings, viz: .287 pounds per day. The lambs fed screenings gained 27¼ pounds for the 95 days while those fed oats gained only 20.9 pounds. The average for all lots was .263 pounds per day.

Considering the results by periods it will be noted that the fastest gain on the average was made during the first perod and the slowest during the second period.

AMOUNT OF FOOD EATEN BY LAMBS.

Table No. 4 gives the food eaten and the cost of the food for each period and for the whole 95 days, by lots.

On the average each lamb ate 2.05 pounds of clover and .81 pounds of grain per day. There was not a very great difference between the amounts eaten by the different lots. Those fed oats ate the most clover and those fed the mixed grain ration the least.

FOOD EATEN FOR EACH POUND OF GAIN BY LAMBS.

The food eaten for each pound of gain on the average was 8.03 pounds clover and 3.11 pounds of grain. The lot fed screenings required the least food for each pound of gain, viz.: 7.73 pounds of clover and 2.82 pounds of grain. The mixed grain ration, wheat, barley and oats follow in the order named. Oats would appear to be the least efficient ration in fattening

lambs, while screenings and the mixed grain rations appear to be the most efficient.

COST OF FOOD EATEN BY LAMBS.

As stated above, while the money cost of a ration does not always afford a safe comparison, yet it is an interesing one, at least to the local people, when prices are similar to those given in the experiment. On the average it cost about 4½ cents per pound for each pound of gain made by those lambs during the 95 days of the test. The lowest cost was with the lambs fed on screenings, viz.: 4.04 cents per pound. The highest cost was with oats, viz.: 5½ cents, or nearly 1½ cents per pound more than for the screenings ration. This is explained by the fact that the screenings was not alone the most efficient but also the cheapest grain ration. The wheat ration at the price given produced gain at ½ cent per pound less than did the barley ration, or 4.5c per pound for wheat ration and 5c for the barley ration. The mixed grain ration produced 1 pound of gain at a cost of 4.5 cents per pound, thus costing about ½ of a cent more per pound than for the screenings.

COMPARISON OF LAMBS AND WETHERS, THE GAIN AND COST OF GAIN.

A comparison of the results in feeding the lambs and wethers, brings out some interesting facts as the table shows.

	Food Eaten Per Day.		Gain Per Day Per Sheep.	Total Gain Per Sheep.	Cost of Food Per Day.	Cost of One Lb. of Gain	Total Cost of Gain Per Sheep.
	Clover.	Grain.					
Lambs...	2.05 lbs.	.81 lbs.	.263 lbs.	25. lbs.	1.21c	4.49c	$1.13
Wethers..	3.22 lbs.	.806 lbs.	.238 lbs.	25.6 lbs	1.5c	6.30c	$1.43

The wethers ate practically the same amount of grain as did the lambs, but they ate 1.17 pounds more clover hay per day.

The lambs gained 2½ pounds more for the 95 days, even though they ate less food. The cost of each pound of gain for the wethers was 6.3 cents while for the lambs it was about 4.5 cents or 1.8 cents less for the lambs. For the 95 days the feed of the wethers cost $1.42 each, while that of the lambs cost $1.13 or 29c less.

Considering the gains only, the lambs were much the more economic feeders, it costing with 100 lambs $29.00 less to produce 2,500 pounds of gain than for 100 wethers to produce 2,266 pounds of gain in live weight. However, because of their size and the cheaper rate at which they were purchased, the wethers proved to be the most profitable to feed as will be noted later.

GAINS MADE BY LAMBS AND WETHERS FOR THE VARIOUS PERIODS.

Another interesting comparison is in the gains made for the various periods by the lambs and wethers.

For the first period of 31 days the wethers on the average made faster gains than did the lambs. For the 2nd and 3rd periods the lambs on the average gained the more rapidly. The young and growing animal maintained the rate of gain better than did the more mature animal.

COMPARATIVE VALUES OF GRAIN RATIONS FOR LAMBS AND WETHERS.

It is noticeable that the best grain ration for the lambs did not prove the best ration for the wethers. With the lambs the wheat screenings proved to be the best grain ration, requiring the least grain for each pound of gain and making the fastest gains. The mixed grain is a very close second. Not alone is the ration

FIG. 1. SHEEP-FEEDING YARDS AND SHED. LAMBS ON THE RIGHT WETHERS ON THE LEFT

FIG 2. THE TYPE OF WETHER FED

of screenings efficient but it is also a cheap ration, producing a pound of gain for 4.04 cents while the mixed grain ration cost 4.3 cents.

These results accord with pervious tests at this Station as reported in bulletins No. 31 and 39. Experiments conducted by the writer at the Utah Station show the same results; the screenings proved the most efficient ration for lambs. The results from feeding the wethers, however, have another story to tell. Neither the screenings, nor the mixed grain proved as efficient or as cheap rations as the various grains, in fact they were the least efficient rations fed. With the wethers, the barley ration gave the best returns, but with the lambs it was, next to the oats, the least efficient ration fed. With the lambs the oats ration gave much the poorest returns, but with the wethers was next to the barley in efficiency and cheapness; wheat occupies an intermediate point with both lambs and wethers. I will not attempt to reconcile these apparent contradictions. They seem to teach that a ration capable of giving the best results with lambs may not be the best for wethers and mature stock. There is room here for further investigation.

THE CLOVER WASTE.

It will be noticed from tables 2 and 4 that there is considerable waste from feeding the clover. To get the sheep to eat as much as possible, they can not be forced to eat the clover too closely, otherwise they will not eat as much nor do as well. Again, much of this clover was from the first cutting after seeding and thus there was considerable old stubble in the hay. The waste from the wethers was 6,830 pounds, or nearly 3½ tons, this was 16½ per cent of the hay fed. The waste from the lambs was 6,655 pounds, a little less than from the wethers, but a larger per cent of the amount fed, namely, 23.6 per cent. As this waste was fed to cattle and horses and practically all eaten, the sheep are not charged with it.

TABLE V.—Lamb Feeding. Summary and Financial Results 1902-3.

Fed 95 Days.	Lot 1 Fed Clover and Wheat Screenings.	Lot 2. Fed Clover and Wheat.	Lot 3. Fed Clover and Oats	Lot 4. Fed Clover and Barley.	Lot 5. Fed Clover and Grain Mixture.	Total.
Number of lambs	21	22	22	22	22	109
Weight at beginning	1405 lbs	1555 lbs	1555 lbs	1597 lbs	1525 lbs	7635 lbs
*Cost of lamb at 2.57c per lb.	$36.12	$39.96	$39.96	$39.96	$39.20	$196.20
Cost of food and cost of feeding each lamb	$22.15	$25.50	$25.29	$26.96	$25.50	$125.40
Total cost of lambs	$57.27	$65.46	$65.25	$66.92	$64.70	$321.60
Weight at close of test	1977 lbs	21.12 lbs	2015 lbs	2132 lbs	2122 lbs	10360 lbs
Net gain	572 lbs	557 lbs	460 lbs	535 lbs	597 lbs	2722 lbs
Gain per lamb	27 lbs	25 lbs	21 lbs	24 lbs	27 lbs	25 lbs
†Received for lambs if sold at 4½c per pound	$88 96	$95.04	$90.67	$95.94	$95.49	$456.10
Profit on feeding	$30.69	$29.58	$25.42	$29.02	$30.79	$144.50
Profit on feeding one lamb	$1.55	$1.34	$1.15	$1.32	$1.40	$1.32
Weight of lambs in Chicago	....	....	....	....	....	9569 lbs
Loss in shipping	....	....	....	....	....	792 lbs
Per cent loss in shipping	....	....	....	....	....	7.6 PrCt
Received for lambs at 7¼c per lb	....	....	....	....	....	$693.70
‡Total cost of shipping with commission	....	....	....	....	....	$81.52
Cost of shipping one lamb	....	....	....	....	....	.75
Value of five lambs lost	....	....	....	....	....	$35.08
Net returns for lambs	....	....	....	....	....	$577.10
Cost of lambs and feed	....	....	....	....	....	$321.60
Profit on feeding	....	....	....	....	....	$255.50
Profit on feeding one lamb	....	....	....	....	....	$2.34

*At $1.80 each or as calculated 2.57 cents per pound.
†The price at which many lambs were sold in the valley last winter.
‡This is calculated on the basis that the cost of shipping would be in proportion to weight of lambs.

THE FINANCIAL RESULTS WITH LAMBS.

We have next to consider the financial results and the record of the experiences from shipping the car of lambs and wethers to Chicago. Table 5 gives the experience with the lambs. This table will repay careful study. The table is arranged to show, first, the returns if the lambs had been sold to dealers at Bozeman, as many of the feeders in the valley did. The profit per

lamb ranged from $1.15 for the lot fed on oats to $1.55 for the lot fed on screenings. Considering the 109 lambs, the purchasing price was $196.20. The cost of the feed was $125.40, making a total cost for lambs and feed of $321.60. The returns for the lambs if sold at 4½c per pound live weight, would have been $456.10. This would mean a return of $144.50 as profit and pay for labor and care in looking after the lambs, or $1.32 for each lamb fed. The cost of feeding is not considered in these results, as in a feeding experiment the labor cost is necessarily excessive. Figuring from the facts given by Mr Broox Martin as quoted in a later part of this bulletin, the labor cost, including every item of expense, is not over 25c for each lamb or sheep fed. This would leave a net profit of $1.07 for each lamb.

THE SHIPPING EXPERIENCE.

The next part of the table shows the results obtained from shipping the lambs to Chicago. The lambs were weighed two days before being shipped and this was taken as the shipping weight. They were loaded on the car in the morning, being driven about two miles to the loading chute.

It will be noticed that they lost 792 pounds on their journey, or 7.6 per cent of their home weight. In Chicago the lambs sold for 7¼ cents per pound, and after deducting the value of the five lambs lost, returned $658.62. The cost of shipping, with commission and all expenses figured on the basis stated, was $81.52, or 75c for each lamb. The net returns, therefore, were $577.10. The cost of the lambs and the feed was $321.60, thus the profit on the feeding, when selling at Chicago prices, was $255.50, or $2.34 for each lamb. As will be noted this was $1.00 more per lamb than would have been obtained by selling in Bozeman at the average price being paid. It should be mentioned, perhaps, as will be noted later, that as these lambs were fed grain nearly all through the test and were thus in extra good condition, they commanded a premium on the Chicago market.

TABLE VI.—Feeding Wethers. Summary and Financial Results 1902-3.

Fed 95 Days.	Lot 1. Fed Clover and Wheat Screenings.	Lot 2. Fed Clover and Wheat.	Lot 3. Fed Clover and Oats	Lot 4. Fed Clover ann Barley.	Lot 5. Fed Clover and Grain Mixture.	Total.
Number of Wethers..........	22	22	22	23	23	112
Weight at beginning of test...	2717 lbs	2725 lbs	2795 lbs	2745 lbs	2832 lbs	13814 lbs
*Cost of wethers at 2.256c per lb	$61.30	$61.45	$63.04	$61.95	$63.85	$311.60
Cost of food..................	$19.88	$32.18	$32.18	$32.18	$30.30	$156.72
Total cost of fatted wethers..	$81.18	$93.63	$95.22	$94.13	$94.15	$468.32
Weight at close of test........	3180 lbs	3232 lbs	3320 lbs	3372 lbs	3247 lbs	16352 lbs
Net gain......................	463 lbs	507 lbs	525 lbs	627 lbs	415 lbs	2538 lbs
Average gain per wether......	21 lbs	23 lbs	24 lbs	27 lbs	18 lbs	2266 lbs
†Received for wethers if sold for 4c per lb. live weight....	$127.20	$129.28	$132.80	$134.88	$129.78	$654.08
Profit on feeding.............	$46.02	$35.65	$37.58	$40.75	$35.63	$185.76
Profit on one wether.........	$2.09	$1.62	$1.71	$1.77	$1.55	$1.66
Weight of wethers in Chicago	....	....	....	....	....	15190 lbs
Loss of weight in shipping...	....	....	....	....	....	1162 lbs
Per cent loss in shipping.....	....	....	....	....	....	7.1 PrCt
Received for wethers at 6c per lb....................	....	....	....	....	....	$911.40
‡Total cost of shipping with commission	....	....	....	....	....	$128.86
Cost of shipping one wether..	....	....	....	....	....	$1.16
Net returns for wethers......	....	....	....	....	....	$782.54
Cost of wethers and feed.....	....	....	....	....	....	$468.32
Profit on feeding.............	....	....	....	....	....	$314.22
Profit on feeding one wether.	....	....	....	....	....	$2.80

*Each wether cost $2.80. This by calculation makes 2¼ cents per pound live weight.
†The price at which many wethers were sold in the valley last winter.
‡This is calculated on the basis that the cost of shipping would be in proportion to the weight of the wethers.

THE FINANCIAL RESULTS WITH WETHERS.

Table 6 shows the financial results with the wethers. Selling at local prices, 4c per pound, the lot fed screenings returned the largest profit, viz.: $2.09 per wether, next comes the barley ration, followed by oats, wheat and the mixed grain ration in the order named. The price paid for the wethers was $2.80 each, but, to put all the lots on an equal basis, the price is figured at

2¼c per pound, which was the actual price paid per pound. The cost of the 112 wethers was $311.60. The cost of the feed was $156.72, making the total cost of the wethers $468.32. Had they been sold at 4c per pound, the price offered by dealers in Bozeman, they would have brought $654.08, giving a profit (which would include pay for labor), of $185.76, or $1.66 profit on each wether. This shows a larger profit on the wethers than for the lambs by 34c each, and this in spite of the fact that the lambs made much the more economic gain in feeding, as is noted in another place.

The explanation of this is given in the following table, and as will be noted, it is due to the increase in the selling price of the original weight of the sheep and also to the difference in the original weight of the lambs and wethers.

To illustrate:

A 123 lb. wether costs at 2.256c a lb.	$2.80
And the 22.6 lb. gain costs at 6.3c per lb.	1.42
Thus the total cost of the wether was	$4.22
But the 123 lb. wether sold for 4.785c a lb. or	5.88
And the 22.6 lb. gain sold for 4.785c a lb. or	1.10
Thus the net price received for the wether was	$6.98

This represents a loss of 32c on the increase made during the fattening period, but a gain of $3.08 on the original weight of the wether, or a net gain of $2.76. The profit arose from the increased value given to the original 123 pounds of the wether by adding 23 pounds in finishing the animal for market.

For the lambs the results are as follows:

A 70 lb. lamb costs at 2.57c per lb.	$1.80
And the 25 lbs. gain cost at 4.49c per lb.	1.13
Or a total cost per lamb of	$2.93
But the 70 lb. lamb sold for 5.573c per lb. or	3.90
And the 25 lbs. gain sold for 5.573c per lb. or	1.39
Or a net return per lamb of	$5.29

This represents a profit of 26c on the gain made on each lamb during the fattening period and a profit of \$2.10 on the original weight of the lamb. This is 98c less than on the original weight of the wether although the lambs increased in value 3c per lb. and the wethers only 2½ cents per pound. Thus the net gain in value on the lambs was \$2.36 but on the wethers \$2.76 or 40c more.

THE SHIPPING EXPERIENCE.

Consider next the experience and results from shipping the wethers to Chicago. They were handled exactly the same as the lambs and shipped in the same car. The loss of weight in shipping was 1162 pounds or 7.1 per cent; about ½ per cent less than for the lambs. The wethers sold at 6c per pound, a total of \$911.40. The cost of shipping on the basis figured was \$128.86 for the 112 head or \$1.16 each. This left a net return of \$782.54. The cost of the wethers and the feed was \$468.32. Thus the profit on the feeding was \$314.22 or \$2.80 each. This was \$1.14 greater profit than if the wethers had been sold at the prices prevailing in the valley.

COMMENTS ON THE QUALITY OF THE STOCK.

The quality of the stock, due first to Mr. John Robinson's careful selection, who purchased the sheep for us, and next to the excellent finish given them, is best illustrated by quotations from the Chicago live-stock papers which are appended.

WEEKLY LIVE STOCK REPORT, CHICAGO.

RECORD PRICES FOR MONTANAS.

"On Friday, March 6, the Montana State Experiment Station marketed at Chicago 96 head of lambs averaging 88 lbs. at $7.25, and 112 wethers averaging 136 lbs. at $6.00. These prices are the highest ever paid on any market for stock raised and fed in Montana. The price paid for the lambs was equal to the best sale of the season up to that date, and the wethers also brought the highest price of the season and the highest paid at Chicago since June last year, when the same figure as reached. The wethers were purchased by Armour & Co., and the lambs by the Schwarzschild & Sulzberger Packing Co.

"The Schwarzschild & Sulzberger Co. report that five head of lambs, of which close record was kept for test, dressed out 54.8 per cent. As 50 to 52 per cent is considered a good average showing, it will be seen that these lambs did very well. Armour & Co. report that five head of wethers dressed 51 per cent."

CHICAGO LIVE-STOCK WORLD.

LAMBS $7.25; WETHERS $6.00.

MONTANA EXPERIMENT STATION MARKETS TWO SPLENDID LOTS.

"Conspicuous in the somewhat inferior run of sheep and lambs today were two bands consigned by the Montana Experiment Station at Bozeman, Mont., that furnished a valuable object lesson to feeders on the advantage of finishing stock before marketing.

"On a bad market the lambs were bought by the 'S. & S.' at $7.25, and the wethers by Armour & Co. at $6.00, the latter being the highest price this year. Both bands will be subjected to a dressing test. As no representative of the Experiment Station accompanied the shipment, details of feeding could not

be obtained. The flock was greatly admired by sheep division talent. * * * This is the highest price ever paid for native Montana lambs finished in the state, the previous high spot being $6.85 last year. It is the highest price ever paid for Montana wethers by a dollar.

"The lambs brought the top price here this season and the wethers 25 cents higher than the previous top.

"Part of the wethers will be sent to Bermuda to furnish the grade of mutton suited to the epicurean taste of the officers of the British garrison there. They were fed experimentally on hay and grain."

CHICAGO DROVERS' JOURNAL.

MONTANA SHOWS GREAT RESULTS.

"A deck of fancy 136-lb. Montana wethers sold at $6.00 this morning, and a deck of fancy 88-lb. Montana lambs at $7.25, the lambs reaching the previous top price of the season and the wethers showing the highest price of the season and the highest price paid here since June last year, when the same figure was reached."

To the Montana feeder the encouraging feature of these comments is that with the right kind of stock, the grains and fodders of Montana will give to the live-stock fattened here the finish that will enable them to compete successfully with the corn fed stock of the middle west. Another thought suggested, perhaps, is that it pays to put the finish on the animals.

PER CENT OF DRESSED MEAT TO LIVE WEIGHT.

A few points brought out incidentally by this test should not be passed over and others should be compared with the experience of previous years.

Dressed Weights, Per Cent.

	1902	1903
Lambs	54.2 Per Cent.	54.8 Per Cent.
Wethers, 1 year	52.9 Per Cent.	....
Wethers, 2 year	53.5 Per Cent.	51.1 Per Cent.
Old Ewes	50.6 Per Cent.	....

Five lambs and five wethers were marked before leaving the Station farm and then killed in Chicago, and from these the dressed weights were obtained. The lambs fed the past winter dressed a little better than did those of the year before but the wethers dressed 2½ per cent less. We are under obligations to Armour & Co., and Schwarzschild & Sulzberger Co., of Chicago, for the facts in regard to this report.

SHRINKAGE FROM TWELVE HOURS FAST.

Live-stock is frequently bought on full weights with 4 per cent deducted as shrinkage, or they are left without food and water for 12 hours and then weighed, this weight being taken as the shrink weight. An attempt was made to find what was the shrinkage by holding the sheep without food and water for 12 hours.

The table gives the results:

	Full Weight.	Shrunk Wt.	Shrinkage.	Shrinkage.
Lambs	10360 lbs.	10175 lbs.	185 lbs.	1.79 Per Cent.
Wethers	16352 lbs.	25850 lbs.	502 lbs.	3 07 Per Cent.

The results show that the lambs shrank a little less than 2 per cent and the wethers a fraction over 3 per cent in live weight by being deprived of food and water for 12 hours.

SHRINKAGE FROM SHIPPING TO CHICAGO.

The next question is the shrinkage in marketing. The weight taken as the shipping weight was the average of weights taken on February 23d and 25th. The sheep were shipped the morning of the 27th. The sheep were weighed, as during the winter, between two and four o'clock in the afternoon, after having had their morning feed of clover and grain. They had access to water at all times. To the table is added the results from previous years.

	Weight Per Lamb in Bozeman.	Weight in Chicago.	Shrinkage.	Shrinkage Per Cent.	Year.
Lambs..........	88 lbs.	80 lbs.	8 lbs.	8.7	1901
"	86.6 lbs.	79 lbs.	7.6 lbs.	8.7	1902
"	95 lbs.	87.8 lbs.	7.25 lbs.	7.6	1903
Wethers.........	129 lbs.	118 lbs.	11.2 lbs.	8.6	1902
"	146 lbs.	135.6 lbs.	10.5 lbs.	7.1	1903
Old Ewes........	107.2 lbs.	95 lbs.	12.2 lbs.	11.3	1902

The loss in shipping is very simliar for the several years, though slightly lower for the past season. The data should give fairly accurate results considering the three years. The shrinkage ranges between 7 per cent and 9 per cent.

COST OF SHIPPING TO CHICAGO.

An important point to be always considered by the local feeder is whether to sell the lambs locally or ship to some central market. To enable the Montana feeder to, in a measure, answer this question, the sheep fed the past three years have been shipped to Chicago and sold on that market. The table shows the cost of shipping for each of the three years.

Cost of Shipping for Three Years, One Double-deck Car.

Year.	No. of Sheep.	Average Weight of Sheep.	Total Cost of Shipping,	Average Cost Per Sheep.
1901	216 lambs	88 lbs.	$181.39	$ .83
1902	55 lambs	86.7 "	42.96	.78
1902	104 wethers	129 "	122.14	1.17
1802	53 ewes	107 "	49.89	.94
1903	109 lambs	95 "	81.52	.75
1903	112 wethers	146 "	128.86	1.16

The average for the three years shows that it cost 78⅔ cents to ship the lambs, $1.16 to ship each wether and 94 cents to ship the old ewes. It should be remembered, of course, that these results are from shipping two or more cars. We shipped with other feeders in the valley.

THE NET PRICE PER POUND RECEIVED AT BOZEMAN--CHICAGO PRICES.

In connection with the cost of shipping, an interesting question is as to the net price per pound, or 100 pounds received for the sheep at the college farm.

The net price received for each lamb after deducting the cost of shipping, etc., was $5.29. Figuring on their weight at Bozeman, viz.: 95 pounds each, this gives a return of $5.57 per hundred pounds at Bozeman.

For the wethers the net price received for each after deducting shipping expenses was $6.98. Again considering the weights at Bozeman, viz.: 146 pounds each, the returns were $4.78 per 100 pounds at Bozeman.

As will be noted, this is considerable above the prices paid in the valley the past winter. There is, however, always a certain amount of risk in shipping, due to the fluctuations in the market, and again these prices were for an extra lot of stock.

THE EXPERIENCES OF SOME OTHER FEEDERS.

In closing the description of the sheep feeding work of the past winter, we wish to place on record the results obtained by a few of the feeders in the state as reported in three of the papers. The following extracts are taken from those reports:

FROM THE GALLATIN FARMER AND STOCKMAN.

PROFIT ON LAMB FEEDING.

"We publish the following statement kindly furnished us by Mr. E. Broox Martin, who has for a number of years past been feeding lambs for the market. A careful record has been kept of all expenses incurred, as shown in the tables which go a long way to prove just what can be done by careful management and keeping correct data:

SHEEP FEEDING STATEMENT.

Bought 1,793 lambs Oct. 4, paid	$3,070.25
Run them on pasture to Nov. 27; pasture cost	93.28
Paid herder	36.00
Nov. 27, put lambs on hay feed, and fed 3 lbs. per day for 83 days, 438,987 pounds a $5.00 per ton	1,097.00
Began feeding grain Dec. 29 and fed 4,000 lbs. of sceenings at 75 cents per hundred	30.00
Also 40,451 lbs. of oats at 85 cents per hundred	420.33
Salt	2.50
Labor to feed lambs	190.00
Board for men while feeding	59.10
Board for teams while feeding	52.12
Shoeing horses	15.00
Interest on capital invested	71.61
Incidentals, provisons for herders, livery etc	20.05
	$5,178.14

CONTRA ACCOUNT.

Feb. 20 sold 1,763 lambs at 4½ cents for	$6,773.34
By 25 per cent of hay cleaned from racks and fed to stock cattle	274.25
By pelts from lambs lost	5.00
	$7,062.59
	5,178.14
	$1,884.45

"The lambs weighed on November 27, when the feeding commenced, an average of 69 pounds. They weighed on February 20, when sold an average of 86⅛ pounds, a gain since feeding commenced, of 17⅛ pounds."

FROM THE DILLON TRIBUNE.

"The finest shipment of sheep that has ever gone out of Beaverhead county, if not the state of Montana, left the Dillon stock yards last Friday. There were almost 1,600 of them.

The sheep were an example of what alfalfa feeding will do in this county.

The wethers were bred and raised by J E. Morse and E. O. Selway, of this city, and were Hampshire and Shropshire crosses. They were purchased by Mr. Hample, of Butte, last December andwere fed *exclusively* on alfalfa hay for the last seventy-four days, during which time they consumed about six pounds of alfalfa each per day. The sheep were weighed when placed on feed and averaged 108 pounds and cost three cents per pound. They were sold at four and a quarter cents per pound, and averaged when weighed last Friday, 137 pounds.

The feeding may be summed up as follows:

Cost of 1,600 sheep at $3.24	$5,840.00
Cost of 363 tons hay at $5.00	1,815.00
Cost of labor, salt etc	197.00
Sundries and death losses	66.20
Total cost	$7,262.20
Total proceeds	9,289.29
Net gain	2,027.09
Profit per sheep	1.27

FROM THE GALLATIN COUNTY REPUBLICAN.

"The following are some of the facts and figures gathered from a few of the farmers who fed sheep the past season and who have recently disposed of their lambs and wethers:

"John M. Robinson fed about 2,400 head of lambs and wethers, the lambs being in the majority. He paid 1.75 for the lambs but when delivered on his ranch they represented a cost of $1.80. The wethers cost delivered $2.80 per head.

"The bunch was fed 90 days on hay. Close figuring showing that the actual cost for hay at 6.00 per ton, during the entire period of feeding was 75 cents. Grain was fed for 47 days and represented an outlay of 21 cents per head for the total period, reckoning the grain at prevailing market prices. The prices received by Mr. Robinson were $4.50 per cwt. for the lambs and $3.60 for the wethers on the home ranch. The lambs weighed on an average a fraction over 85 lbs. and the wethers 146⅔ lbs. each. The loss during the entire feeding season was about 1 per cent. One animal was lost from bloat, a couple got on their backs and were too fat to right themselves and several died from unknown causes.

"Charles Miller fed 1,400 lambs and paid $1.80 per head for them, and fed for two months, in addition to pasturing during November, the feed being clover and oats. Mr. Miller raised for the purpose of feeding his sheep 150 tons of clover hay from 40 acres of land, all of which he fed during the two months.

"In addition to hay he fed 52,000 lbs. oats. He figured the hay was worth on his ranch about $4.50 per ton and the oats 75 cents per cwt. The lambs at the time they were sold weighed on an average 85 lbs. These sheep were weighed after being without food or water for 12 hours, and driven three miles to scales. The price received was 4½ cents per cwt. The loss was greater than Mr. Robinson's owing to the fact, probably, that this is Mr. Miller's first exeprience. During the season he lost 30 head, some from bloat, others rolled over on their backs and could not get up, and some from unknown causes. The work of feeding and caring for these sheep was done by Mr. Miller without any

help. In addition to the sheep Mr. Miller fed 50 head of steers on the 'leavings' of the sheep; these are in very good condition and with a little grain and hay would make beef in a few weeks.

"To show the net gain of the two months feeding by Mr. Miller, we present the following table:

1,400 lambs at $1.80	$2,500.00
150 tons hay at $4.50 per ton	675.00
2,000 lbs. oats at 75c per cwt	390.00
2 months wages at $50 per month	100.00
Cost	$3,685.00
1,400 lambs at 4½ cents, 85 lbs	$5,355.00
30 head loss	114.75
	$5,240.25
Less Cost	3,685.00
Net gain	$1,555.25

"This does not allow anything for the keep of the steers.

"The principal thing is to buy the right kind of stock, and above all things do not buy old toothless ewes. Then the feeder should have good shelter, plenty of fresh open water for the stock to drink whenever it please.

"Mr. Robinson fed hay twice a day, morning and evening, and grain at noon. His hay was weighed for the first three or four weeks so that he might know just how much he was feeding per head. Like Mr. Miller he trailed some cattle to clean up the leavings of the sheep and with the addition of a little fresh hay kept them nice and fat."

ACKNOWLEDGMENTS.

For help in the selection of this car lot of sheep our thanks are due to Mr. J. M. Robinson of Bozeman, and for help in shipping to Chicago we are indebted to Mr. Maxey of Bozeman. We are also under obligations to Clay, Robinson & Co. for the sale made and to Armour & Co. and Schwarzschild & Sulzberger Packing Co. for the results of the slaughter tests at Chicago.

SUMMARY AND CONCLUSION.

(1) For the lambs, the screenings proved the cheapest and most efficient grain ration, followed by mixed grain, wheat, barley and oats in the order named.

(2) The lambs ate 2.05 pounds of clover and .81 pounds of grain a day while the wethers ate 3.22 pounds of clover and .806 pounds of grain.

(3) The lambs averaged .263 pounds gain in live weight a day, or 25 pounds for the full term of the experiment. The wethers averaged .238 pounds per day or 22⅔ pounds for the 95 days.

(4) The lambs ate 8.03 pounds of clover and 3.11 pounds of grain for each pound of increase in live weight. The wethers ate 13.49 pounds of clover and 3.38 pounds of grain for each pound of increase.

(5) Each pound of increase in live weight put upon the lambs cost 4.49 cents while each pound of increase on the wethers cost 6.3 cents.

(6) Lambs kept without food or water for 12 hours shrank nearly 2 per cent. Wethers similarly treated shrank 3 per cent in weight.

(7) In shipping to Chicago each lamb shrank 7¼ pounds or 7.6 per cent. On the average for three years they shrank 8.3 per cent of their shipping weight. The wethers lost 10.4 pounds each or 7.1 per cent of their shipping weight, or for two years, 7.8 per cent of their shipping weight.

(8) For the past winter it cost on the average 75 cents to ship and sell each lamb at Chicago and $1.16 for each wether. On the average for three years it cost 78⅔ cents to ship and sell one lamb and $1.16½ to ship and sell one wether.

(9) The net prices received for the lambs F. O. B. Bozeman was $5.57 per 100 pounds live weight and for the wethers $4.78 per 100 pounds.

(10) The profit, or return for money invested and pay for the labor, on each lamb, by shipping to Chicago was $2.34 and the profit on each wether was $2.80. Or taking the results of the practical feeder and charge 25 per cent for the labor cost of feeding, the return on the investment was $2.09 for the lamb and $2.55 for the wether.

(11) In the slaughter test the lambs dressed 54.8 per cent and the wethers dressed 51 per cent of the live weight at Chicago.

BULLETIN NO. 48.

MONTANA

AGRICULTURAL

EXPERIMENT STATION

--OF--

THE AGRICULTURAL COLLEGE

--OF--

MONTANA.

STEER FEEDING.

WINTER OF 1902-1903.

BOZEMAN, MONTANA, SEPTEMBER, 1903.

BOZEMAN CHRONICLE--1903.

MONTANA AGRICULTURAL
EXPERIMENT STATION.

STATE BOARD OF EDUCATION.

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MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

EXPERIMENTS IN STEER FEEDING, 1902-3.

By F. B. LINFIELD.

CONTENTS.

NOTE—Through an oversight, Bulletin No. 47 was paged independently of the other series of the year. This Bulletin returns to the consecutive paging

STEER FEEDING.

INTRODUCTION.

For the past three seasons the Montana Experiment Station has conducted experiments in fattening steers, to test the feeding value of various kinds of Montana fodders. During the past winter a carload of steers were fed, the object of the experiment being to determine the relative value of different kinds of grain when fed with clover in fattening steers. The question is frequently asked as to the relative value of oats, wheat, barley, etc., for fattening animals and this experiment was planned to throw some light on the subject.

The 24 steers used in the test were a mixed lot of two and three year olds, range stock of probably average quality. The most of them showed evidences of some little Short Horn blood. They arrived on the farm on the 23rd of November. On the 28th, one-half of the steers which were not dehorned, were driven to a dehorning chute and the horns sawed off. The wounds healed rapidly and with no apparent disadvantage to the steers.

PLAN OF EXPERIMENT.

The 24 steers were divided into four lots, six steers in each lot. The division was made as evenly as possible considering quality and weight. The lots were fed as follows:

Lot 1. Wheat and clover hay.

Lot 2. Oats and clover hay.

Lot 3. Barley and clover hay.

Lot 4. Wheat, oats and barley mixed in equal quantities, by weight and clover hay. All the grain was chopped.

The experiment started on December 1st. For the first ten days clover hay was fed. We then started to feed the grain, giving three pounds per day to each lot and about one month was taken to get the steers onto a full feed of five pounds of grain per steer per day. The hay and the grain were fed twice in the day.

The steers were weighed on December 1st and 3rd, and again on the 10th and 12th of December, and thereafter every two weeks until the close of the experiment. The average of two days weights was taken as the correct weight.

Water was flowing through the yards, thus the steers had access to water at will. Salt was also kept on hand.

COST OF THE FEED.

The cost of the grain and fodder fed was as follows:

Clover hay	$5.00 per ton
Wheat	88c per 100 lbs.
Oats	85c per 100 lbs.
Barley	95c per 100 lbs.
Bran	85c per 100 lbs.
Mixed Grain	89c per 100 lbs.

These prices were practically the market prices for the hay and grain on the Bozeman market in the fall of 1902. The clover hay was of good quality and generally well cured. It was a mixture of medium red and alsike. The grain was good marketable grain.

TABLE I.—Weights and Gains of Steers.

Period	Lot and How Fed.	Weight at beginning of experiment and of each period.	Weight at end of periods and of test.	Gain for each period and total gain.	Average daily gain per steer.	Average gain per steer
		lbs.	lbs.	lbs.	lbs.	lbs.
First period	1. Wheat and clover hay.....	6675	7040	365	1.64	60.84
Dec. 1st to	2. Oats and clover hay.......	6507	6830	323	1.45	53.84
Jan. 6th.	3. Barley and clover hay.....	6470	7002	512	2.40	88.63
37 days.	4. Mixed grain and clover hay	6702	7315	613	2.76	102.18
Second period	1. Wheat and clover hay.....	7040	7540	500	2.98	83.34
Jan. 7th to	2. Oats and clover hay.......	6830	7120	290	1.73	48.34
Feb. 3rd.	3. Barley and clover hay.....	7002	7480	478	2.87	79.67
28 days.	4. Mixed grain and clover hay	7315	7875	560	3.33	93.34
Third period	1. Wheat and clover hay.	7540	7685	145	1.07	24.17
Feb. 4th to	2. Oats and clover hay.......	7120	7245	125	1.00	20.83
Feb. 24th.	3. Barley and clover hay.....	7480	7550	70	.55	11.67
21 days.	4. Mixed grain and clover hay	7875	7962	87	.69	14.50
Two periods	1. Wheat and clover hay.....	7040	7685	645	2.19	107.50
from Jan. 7th	2. Oats and clover hay.......	6830	7245	415	1.41	69.17
to Feb. 24th.	3. Barley and clover hay.....	7002	7550	548	1.86	91.34
49 days.	4. Mixed grain and clover hay	7315	7962	647	2.20	107.84
Three periods	1. Wheat and clover hay.....	6675	7685	1010	1.96	168.34
from Dec. 1st	2. Oats and clover hay.......	6507	7245	738	1.43	123.00
to Feb. 24th.	3. Barley and clover hay.....	6470	7550	1080	2.09	180.00
86 days.	4. Mixed grain and clover hay	6702	7962	1260	2.44	210.00
Fourth period	1. Mixed grain and clover hay	7685	8075	390	2.60	65.00
Feb. 25th to	2. Mixed grain and clover hay	7245	7635	390	2.60	65.00
March 21st.	3. Mixed grain and clover hay	7550	7960	410	2.73	68.34
25 days.	4. Mixed grain and clover hay	7962	8387	525	3.50	87.50
Whole time	1. Wheat and clover hay.....	6675	8075	1400	2.10	233.35
Dec. 1st to	2. Oats and clover hay.......	6507	7635	1128	1.69	188.00
March 21st,	3. Barley and clover hay.....	6470	7960	1490	2.34	248.36
111 days.	4. Mixed grain and clover hay	6702	8387	1685	2.53	280.83
	Average for 24 steers.........	26354	32057	5703	....	......
	Average per steer............	1097	1336	....	2.15	239.00

TABLE II.—Food Eaten by Steers and Cost of Same.

Period.	Lot	How Fed.	Total Food Eaten.		Food Eaten Per Day Per Steer.		Food Eaten for One Pound Gain.		Cost of Feeding	
			Clover.	Grain.	Clover.	Grain.	Clover.	Grain.	Per Day Per Steer.	Per One Lb. Gain.
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cents.	Cents.
First	1	Wheat and clover hay....	5435	512½	24.5	2.31	14.9	1.44	8.15	4.99
Dec. 1 to	2	Oats and clover hay..........	5440	511½	24.5	2.30	16.8	1.58	8.08	5.44
Jan. 6	3	Barley and clover hay.......	5440	508½	24.5	2.29	10.2	.95	8.3	3.45
37 Days.	4	Mixed grain and clover hay..	5440	513½	24.5	2.31	8.7	.83	8.18	2.93
Second	1	Wheat and clover hay........	4720	835	22.1	4.97	9.44	1.67	9.8	3.82
Jan. 7 to	3	Oats and clover hay..........	4720	840	22.1	5.00	16.2	3.24	9.8	6.80
Feb. 3	3	Barley and clover hay........	4730	840	22.1	5.00	9.89	1.77	10.3	6.62
28 Days.	4	Mixed grain and clover hay..	4720	840	22.1	5.00	8.42	1.5	10.0	3.44
Third	1	Wheat and clover hay........	3675	492	29.0	3.9	25.3	3.39	10.68	9.30
Feb. 4 to	2	Oats and clover hay..........	3675	630	29.0	5.0	29.3	5.04	11.50	11.61
Feb. 24	3	Barley and clover hay........	3575	630	28.4	5.0	52.5	9.00	11.85	21.67
21 Days.	4	Mixed grain and clover hay..	3575	630	28.4	5.0	42.2	7.24	11.56	16.61
Two Periods	1	Wheat and clover hay........	8395	1327	28.5	4.51	13.0	2.06	11.19	5.06
from Jan. 7th	2	Oats and clover hay..........	8395	1470	28.5	5.0	20.2	3.54	11.37	8.05
to Feb. 24th	3	Barley and clover hay........	8305	1470	28.2	5.0	15.1	2.68	11.75	6.32
49 Days.	4	Mixed grain and clover hay..	8295	1470	28.2	5.0	12.8	2.27	11.51	5.22
Three Periods	1	Wheat and clover hay........	13830	1839½	26.8	3.56	13.7	1.82	9.83	4.02
from Dec. 1st	2	Oats and clover hay..........	13835	1981½	26.8	3.84	18.7	2.68	9.96	6.945
to Feb. 24th.	3	Barley and clover hay........	13745	1978½	26.6	3.84	14.9	2.15	10.29	6.067
86 Days.	4	Mixed Grain and clover hay..	13735	1983½	26.6	3.84	10.9	1.57	10.05	4.127
Fourth Period	1		4540	750	30.3	5.	11.14	1.95	11.98	4.501
from Feb. 25th	2		4540	750	30.3	5.	11.14	1.95	11.83	4.442
to Mar. 1st	3		4540	750	30.3	5.	11.08	1.83	12.33	4.508
25 Days.	4		4540	750	30.3	5.	8.65	1.24	12.03	3.269
Whole Time	1	Wheat and clover hay........	18370	2589½	27.6	3.9	13.1	1.85	10.33	5.903
Dec. 1st to	2	Oats and clover hay..........	18375	2731½	27.6	4.1	16.3	2.42	10.38	6.132
Mar. 21st.	3	Barley and clover hay	18285	2728½	27.5	4.1	12.3	1.83	10.77	4.812
111 Days.	4	Mixed grain and clover hay..	18275	2733½	27.4	4.1	10.9	1.62	10.51	4.176
		Average for 24 steers.........	73305	10783	27.5	4.05	12.8	1.9	10.5	5.206
		Average for 1 steer...........	3054	449	....	....	....	....	.....	.....

DISCUSSION OF RESULTS.

Tables 1 and 2 give the facts gleaned during the feeding test. The whole time of the feeding test is divided into periods so as to note any change in the weight or gain during the time of feeding. The first period of 37 days was really preliminary. For ten days of this time the steers received hay only, and the rest of the peried was taken in getting the steers up to a full grain ration. None of the steers apparently, had ever seen grain before and it took a little coaxing to get some of them to eat it. We first started by mixing a little salt with bran, and later cut down the hay ration for a day or two. Finally all started to eat the grain except one steer in lot 3. This animal never ate any grain during the time of the test. His ration was eaten by the others.

The test period proper was for the next 49 days, but this is also divided into two periods, as it was noted that in the latter part of the period the steers seemed to be getting tired of the grain. Because of this fact the test proper was concluded after the steers were on feed 86 days, but the steers not being ready for market, all the lots were fed for 25 days longer, on a mixed grain ration with bran. The tables afford opportunity for several comparisons during the feeding season.

THE GAINS MADE.

For the first period of 37 days, lot 4 gained the most, viz.: 2.7 lbs. per day per steer, with lot 3 in second place, gaining 2.4 pounds per day. Lots 1 and 2 gained nearly 1 pound less per day per steer. For the first part of the test period, viz.: 28 days, lot 4 gained 3.33 pounds per steer per day. This lot averaged 3 pounds per day for the 65 days feeding to this date. Lot 1 fed wheat jumps to second place with a gain of 2.98 or nearly 3 pounds per steer per day. Lot 3 fed barley, is a close third with the lot fed oats very much behind.

FIG. 3 THE BEST STEER IN THE CAR LOAD

FIG. 4. THE STEERS, THE SHEDS AND THE FEEDING CORRAL

FIG. 1. A POOR TYPE OF FEEDING STEER

FIG. 2. A COARSE, ROUGH STEER

All of the lots fell off during the third period, or second part of the test period. The lots that made the best average gain during the first 65 days of feeding made the poorest gains for this period.

Considering the test period proper of 49 days; the steers fed on the mixed grain ration made the fastest gain, viz. 2.2 pounds per day per steer. The lot fed wheat is a very close second, gaining 2.19 pounds per day per steer, while those fed barley gained 1.86 pounds per day per steer, and those fed the oat ration only 1.41 pounds per steer per day, or the poorest returns of any ration.

Considering next the whole time of feeding of 86 days, the mixed grain ration produced the fastest gain with barley second, followed by wheat, while the oats ration produced the slowest gain.

For the fourth period of 25 days, after the change of the grain ration, the most rapid gains of the test were made. Lot 4 gained 3.5 pounds per steer per day, lot 3 gained 2.7 pounds per steer per day, and lots 1 and 2, 2.6 pounds per steer per day.

For the 111 days of the feeding season, lot 4 gained 2.5 pounds per steer per day, a very satisfactory gain considering the length of the feeding period, lot 3 gained 2.3 pounds per steer per day, lot 1 gained 2-1 pounds and lot 2 gained 1.7 pounds per steer per day.

On the average each steer gained 239 pounds in live weight, increasing from 1097 pounds to 1336 pounds each or 2;15 pounds per day.

FOOD EATEN PER DAY AND PER ONE POUND GAIN.

Table 2 gives the amount of food eaten, the food eaten per day, the food eaten for each pound of gain and the cost of the food. As with the weights, this table is divided into periods to show the results at different stages of the feeding.

The clover eaten per day for the first, or preliminary period, was 24.5 pounds per day per steer. For the first period on full feed the amount of clover eaten per day was 22 pounds, for the next period about 29 pounds per day. Evidently the slower gains for this period were not due to any decsease in the hay eaten. Dur-

ing the fourth period 30.3 pounds of clover were eaten per day per steer and for the whole feeding test the average was 27.5 pounds of clover per day.

As the total amount of feed eaten by the various lots is practically the same, the amount of food for each pound of gain is in inverse relation to the gains made throughout all the periods.

For the test period of 49 days, lot 1 fed on wheat and clover and lot 4 fed on mixed grain and clover required practically the same amount of food for each pound of gain, viz: 15 06 pounds. The lot fed barley required 17.78 pounds of food for one pound of gain and the lot fed oats required 23.74 pounds, the least efficient ration.

Considering the whole time of the experiment, or 111 days, lot 4 required the least food for each period of gain, viz:12.5 pounds. Lot 3 required 14.13 pounds. Lot 1 required 14.95 pounds and lot 2 required 18.72 pounds of food for each pound of gain in live weight.

COST OF THE FOOD EATEN.

Considering next the cost of the rations: For the first period the daily cost was about 8c per day. For the test period of 49 days the cost was between 11c and 12c per day. The barley ration being the most expensive, followed by mixed grain, oats and wheat in the order named. For the whole time of feeding the average cost was 10.5c per day.

In this connection the cost of one pound of gain is the important factor. For the preliminary period the cost ranged from 3 to 5½ cents for each pound of gain. For the test period of 49 days, the cost of 1 pound of gain ranged from 5c to 8c. Lot 1, fed wheat, made the cheapest gain, viz: 5c per pound. The gain on lot 4, fed mixed grain, cost 5.22 cents per pound. For lot 3, fed barley, the cost was 6.32 cents per pound, and for lot 2, fed oats, the cost was 8 cents for each pound of gain.

Considering the whole time of feeding, or 111 days, each pound of gain cost on the average, 5.2 cents, The range was from 4.2 cents for lot 4, to 6.1 cents for lot 2.

THE FINANCIAL RESULTS.

The steers were purchased for us by Mr. Joseph Kountz of Bozeman. Twenty-one of them cost $40.00 each or $840.00 and three cost $41.00 each or $123.00, a total for the 24 of $963.00. The following table gives the financial results of the feeding:

TABLE III.—Financial Statement.

	LOT 1. Fed clover and Wheat.	LOT 2. Fed clover and Oats	LOT 3. Fed clover and Barley.	LOT 4. Fed clover and Mixed Grain.	Average and Totals
Number of steers	6	6	6	6	24
Weight at beginning	6675 lbs	6507 lbs	6470 lbs	6702 lbs	26354 lbs
(a) Cost of steers at 3.652c per lb	$ 243.77	$ 237.64	$ 236.28	$ 244.85	$ 963.00
Cost of food per lot	68.82	69.13	71.72	70.00	279.67
Cost of food per steer	11.47	11.52	11.95	11.66	11.65
Total cost of steers	312.59	306.77	308.00	314.85	1242.67
Weight at close of experiment	8075 lbs	7635 lbs	7960 lbs	8387 lbs	32057 lbs
Net gain in pounds	1400 lbs	1128 lbs	1490 lbs	1685 lbs	5703 lbs
Shrunk weight of steers	7800 lbs	7370 lbs	7685 lbs	8050 lbs	30907 lbs
Per cent shrink on full weight	3.4	3.47	3.45	4.25	3.58
Received for steers @ 4c a pound shrunk weight	$ 312.00	$ 294.80	$ 307.40	$ 322.00	$1236.28
Received per head for each steer	50.33	49.13	51.23	53.66	51.09
Profit or loss on feed	*0.57	*11.97	*0.60	†7.15	*6.39
Profit or loss on each steer	*0.10	*1.99	*0.10	†1.19	*0.26

(a) Note: The steers cost as stated above $40 and $41 each, but to place each lot on an equal basis, the lots are figured on the calculated price per pound.
* Loss.
† Profit.

The steers cost on the average $3.65 per 100 pounds live weight. The cost of the food for each lot ranged from $68.82 for lot 1 to $71.72 for lot 3. The difference in this item is but slight for all the lots. The cost of the food for each steer for 111 days ranged from $11.47 to $11.95. Lot 1 cost the least and lot 3 the most. The average cost for the 24 head was $11.65 each.

After being kept without food or water for 12 hours, the steers shrank from 3.4 per cent to 4.25 per cent of their full weight. The average for the 24 head was 3.58 per cent. This is slightly less than the shrink usually estimated in buying, viz: 4 per cent. The returns per head for the steers ranged from $49.13 each for the steers in lot 2 to $53.66 for the steers in lot 4.

Lot 4, the steers fed the mixed grain ration, returned a profit of $1.19 per steer after paying for the feed; the only lot that returned any profit. On lot 2, fed the ration of oats with clover, the loss was about $2.00 on each steer, on lots 1 and 3 the loss was 10c for each steer. From a financial point of view this looks like rather a poor showing, yet the experiment is none the less valuable because of that fact. It will perhaps, better enforce the lesson that, as a rule, in finishing steers for market there has to be a wider margin of profit between the buying and selling price than was the case in this instance with Montana prices for fodders. These steers were bought, on a shrunk weight, at about 3.8 cents per pound and sold for 4 cents per pound, shrunk live weight. For profit the margin between the buying and selling price should be from ¾c to 1c per pound.

There is yet another compensating point to consider. The results came very close to paying market prices for the hay and grain fed, and if through his stock the farmer can get market prices for his crop on his farm, both the farm and the farmer are better off for having them so sold. At market prices he has the profits on his summer's harvest, while the manure adds much to the fertility of the land.

WHERE THE PROFITS COME FROM.

Briefly put, the profit in the fattening of this class of steers is in the difference in the buying and selling price of the original weight of the steer and not in any profit on the increase in live weight made during the feeding period. This is illustrated in the following figures, giving the cost of the gains made for the past three years in feeding experiments at this station.

Cost of 100 Pounds of Gain.

	1901	1902	1903
Lot 1	$4.85	$4.00	$5.90
Lot 2	$5.16	$4 81	$6.13
Lot 3	$5.31	$5.80	$4.81
Lot 4	....	....	$4.17
Average	$5.11	$4.87	$5.26

These figues are comparable only in a general way, as the steers differed in weight and quality. They show in every case, however, that each 100 pounds of increase in live weight cost close to $5.00 on the average, a little above or below that figure. At average prices, therefore, there can be no profit on this increase in live weight; it must come from the increase in value of the original weight of the animal.

ILLUSTRATIONS.

Figure 1 represents a type of undesirable steer, long legged, slab-sided, wild and restless. Only on the range could there be any profit in growing such an animal. The profit in fattening him would depend on the price at which he was purchased.

Figure 2 shows a coarse rough steer that might gain in live weight rapidly enough, but, however well fatted, would never sell at, or near, the top of the market.

Figure 3 represents the best feeding type of steer among the car load; a two year old with some width and depth of body, a good back and loin and good feeding quality.

Figure 4 shows the steers, and the sheds and yards in which they were fed. The sheds and yards were kept well bedded and it was noticed that the steers sought the shelter of the sheds nearly every night.

SUMMARY AND CONCLUSION.

(1) No one feeding experiment can definitely answer the questions it aims to solve. The work must be repeated for some years and under a variety of conditions. The results here given are tentative and must wait future confirmation.

(2) According to this test a mixed grain ration proved superior to any one variety of grain. If the feeding efficiency as to rate of gain for mixed grain was placed at 100, then wheat equals 99.5 oats 84 and barley equals 84.5.

(3) From the standpoint of the food eaten for 100 pounds of gain in live weight, the wheat ration is very slightly better than the mixed grain, with oats andbarley the same as on the basis of rate of gain.

(4) For the test period the wheat was also the cheapest ration, one pound of gain costing 5 cents on this ration, while the cost on the mixed grain ration was 5.2 cents, on the barley ration the cost was 6.3 cents and on the oats ration 8 cents per pound of gain.

(5) It was noticed that the cattle tired of the wheat after a couple of months feeding and a change was necessary to get the cattle to continue to eat grain. This was true of all the grains fed but not to the same extent as with the wheat.

(6) After a gradual change of the rations to mixed grain with bran the cattle ate the mixture with relish and made the most rapid gains of the winter.

(7) The experiments made at the Station for the past three years seem to show that on the average the profit to be made in fattening two to three year old steers, with Montana prices for feeding stuffs, must come from an increase in the value of the purchased weight of the steer.

(8) This fact, however, does not make less important the study of the relative values of feeding rations. In this test the difference in returns between the best and the poorest ration was $3.52 per steer, by no means an unimportant item in feeding a bunch of steers. For instance, lot 4 gained in live weight 281 pounds worth at 4 cents per pound, $11.24, while lot 2 gained only 188 pounds worth at 4 cents per pound $7.52, or a difference of $3.72: but lot 2 cost 20 cents less to feed so that the net difference was $3.52. On a hundred steers this would mean $352.00 as the difference in returns from feeding the two rations.

BULLETIN No. 49.

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

Contagious Abortion in Montana

Bozeman, Montana, October, 1903.

BOZEMAN REPUBLICAN—1903

MONTANA AGRICULTURAL

Experiment Station.

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MONTANA EXPERIMENT STATION,

Bozeman, Montana.

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Contagious Abortion in Montana,

BY H. C. GARDINER.

CONTENTS.

Montana Experiment Station.

BULLETIN NO. 49. OCTOBER, 1903.

Contagious Abortion in Montana.

BY H. C. GARDINER.

Introduction.

Contagious abortion as a disease is considered of significance almost equal to tuberculosis, and is prevalent both in Europe and America. As a result of its widespread distribution and serious nature it has been carefully investigated on both continents, and particularly in Scotland, Denmark and France, where very serious losses have been experienced. In affected districts in Europe the losses run from twenty to sixty per cent and the average for all herds is five per cent. In an epidemic in the Mississippi valley in 1889 the losses reached seventy-five per cent. Under such conditions breeding has to be entirely abandoned.

The work of the Scottish Abortion Committee, and particularly the work of Professor Bang, the Danish veterinarian, and of Professor Nocard, of France, has been of the greatest importance. Professor Bang succeeded in isolating the germ which causes contagious abortion and it is upon the treatment recommended by him that the disease has been successfully combated.

The attention of the writer was called to the existence of contagious abortion in Montana by an inquiry made at the Experiment Station by Mr. James White, of Bozeman, who was having trouble from this cause. On investigating this case it was found that for several years losses had occurred in the immediate neighborhood of Mr. White's ranch, ranging as high as seventy per cent. The disease in this instance had been gradually spreading in that locality from herd to herd and this spring the first season it affected Mr. White's herd

his loss was about thirty per cent. In order to determine to what extent this disease prevailed in the surrounding country about one hundred letters were sent to stockmen in Gallatin and Madison valleys briefly describing the disease and requesting replies to the following questions:

1. How many of your cows aborted this year?
2. How many of your cows aborted last year?
3. How many cows have you in your herd?
4. Have you heard of anyone in your locality having trouble? Please give name and address.
5. What was the extent of their losses?

From one hundred and five letters of inquiry seventy-seven replies were received, and of the seventy-seven, thirty-eight were from parties having trouble; the losses ranging from ten to eighty per cent. In getting these figures losses which were small and in all probability due to accident were not included, only those being considered which gave evidence of being the result of contagious abortion. In one instance a case came to our notice in which there had been a total loss extend-over a period of three years.

We have also found that abortion is causing loss in various parts of the state. In Teton county the disease, as one stockman expressed it in writing us, "is giving serious trouble." Losses are also reported from Chouteau, Valley, Cascade, Fergus and Powell counties and along the Yellowstone.

From the apparent general distribution of the disease, its wide-spread prevalence in the locality investigated and its contagious nature, it certainly demands the prompt attention of the stockmen of Montana if further serious losses are to be avoided. So serious has it become in portions of Gallatin Valley that we have heard on reliable authority that some stockmen have contemplated abandoning cattle raising for a time until they were satisfied they could avoid the disease; and for the present, at least, contemplate reducing their herds. A disease which menaces the stock raising industry of the state is a danger which menaces the welfare of the whole community and we feel that every effort should be made on the part of the stock associations, the agricultural

press, and the stockmen individually to stamp out this disease. That such efforts are successful are shown by the fact that in some eastern states where the disease was very prevalent ten to fifteen years ago it has been entirely eradicated and sections which had a yearly loss of from twenty-five to forty per cent are now free from the disease.

Definition and Kinds of Abortion.

Synonyms: Contagious abortion, infectious abortion, enzootic abortion, epizootic abortion.

Abortion, or as it is popularly called, "slinking; slipping, casting, or losing" the calf implies premature birth of the fœtus (unborn calf); a separation of the fœtus from the uterus (womb) and membranes before full term. Strictly speaking, a parturition in which the offspring is mature enough to live is called a premature parturition or premature delivery and one in which the offspring is not developed enough to live a separate existence is called an abortion. We will term all premature births abortions in this Bulletin.

There are two forms of abortion dependent upon the cause. The one accidental or sporadic abortion and the other contagious or enzootic abortion caused by a germ. Under some circumstances both causes may bring about abortion.

The causes of accidental or sporadic abortion may be enumerated briefly as: mechanical injuries. such as slipping, falling, being hooked, jammed, kicked, etc.; the diseased condition of the dam, insufficient or innutritious forage, early breeding, in and in breeding, purging as the result of the administration of drugs or the ingestion of poisonous plants, from musty or easily fermentable fodder, from ergotized grasses or grain,* from shock resulting from storms and exposure, from premature death of the fœtus owing to twisting of the umbilical cord, and

* While visiting in Beaverhead county recently, the writer observed a very large amount of native rye grass that was very badly affected with ergot, the heads of rye in many cases being almost black with the long spikes of ergot protruding from the chaff on the head. While, with the other feed available, the stock would probably not eat these dry stalks of rye grass, yet if feed was scarce, they might eat considerable of it.

Upon inquiry it was found that in some seasons the stock running in this field were troubled more or less with abortion, but the owner had not recognized or thought of the ergot as a cause. Later, ergotized rye was noticed in other parts of the state and it was thought, therefore, not amiss to call attention to this danger. F. B. LINFIELD, Dir.

from the odor of decomposed animal matter or any other source which greatly excites or irritates.

The primary cause of contagious abortion is a germ which Professor Bang isolated in 1896 and with which he experimentally inoculated cattle and in nearly every case produced an abortion. In these experiments he chose animals from herds which were known to be free from the disease, and he found the germ in those aborting animals he inoculated and in the fœtuses.

The germs which produce abortion are found between the attachments of the afterbirth and the womb; and here they develop and bring about a catarrh of the uterus and also an inflammation of the afterbirth, at the same time depositing a secretion between these tissues which gradually forces them apart and as a result destroys the circulation in the membranes surrounding the calf and cuts off its supply of nourishment. In the experimental inoculation a period of ten weeks was found necessary before abortion was produced.

Symptoms.

Owing to the diseased conditions of the mucous membrane contagious abortion sometimes takes the form of temporary sterility, the animal coming iu "heat" but failing to conceive. If conception takes place the abortion usually occurs after the fœtus has attained a considerable development, usually occurring from the third to the seventh month. Occasionally the early symptoms pass unnoticed, but in most instances there will be some heat and an enlargement of the udder and a discharge from the vulva of a white or yellow mucous which is very unlike the normal transparent mucous which discharges during heat. After abortion the membranes are usually retained and in some cases a putrid discharge continues for some time. The afterbirths in such cases should be carefully removed, the animal disinfected and not bred again until in a healthy condition.

Immunity.

Abortion, like many other germ diseases, confers immunity after attack, and in this case cattle usually acquire an immunity after from one to five attacks. In general it is probable that the average cow

becomes immune after from one to three attacks. This immunity,, however, loes not prevent the animal from transmitting the disease to the remainder of the herd and she may still be a source of danger to the bull and to the cows she may come in contact with, Herds too, occasionally become free from the disease after a comparatively severe attack and cases are recorded where after a severe attack the disease has wholly disappeared. In some instances it breaks out again and unless proper means are taken to prevent re-infection and to stamp it out there is always the uncertainty of a future attack and in most instances a more or less severe continuation of the trouble as new animals are added and as the heifers are bred. In some years the disease is much more severe than others depending probably upon climatic conditions or other conditions favorable to the development or preservation of the germs.

Means of Transmission.

Any means which will transfer the germs from the genital parts of one animal to another is a method of transmission. The primary source of infection it is generally conceded by all investigators and veterinarians is from the bull. Bred to an infected animal the bull becomes infected and in a most perfect manner infects the remainder of the animals to which he is bred, We have noted three cases in particular in which the bull has been responsible for the infection of a herd. In two instances the bull was purchased from a herd which was infected and taken to a herd which had previously been entirely free from the disease, the result was that the next season both herds, previously uninfected, were aborting badly. Another instance in which a neighbor's bull from an aborting herd broke through a fence into a pasture with a herd that had previously been uninfected and the result was that fifty per cent of the previously uninfected herd aborted that year. Many similar cases are recorded by investigators in Europe.

Another source and probably one of minor importance in Montana is the infection which comes from animals coming in contact with walls. litter, etc. in stables, which have previously been infected by coming in contact with the mucous or catarrhal discharge from in-

fected animals. Still another source of infection and probably the one second in importance comes from the habit which cattle have of smelling and rubbing their noses on each other and transferring the the bacteria by this means and further by cattle jumping each other when in "heat."

Treatment.

The treatment advised for contagious abortion is wholly one of disinfection, and since the germs causing this disease is localized on the genital organs it is a comparatively easy matter to fight them. Where cattle are stabled and are aborting the stables must be thoroughly disinfected and the aborting ones separated from the healthly stock. This condition, however, will apply to few herds in Montana, but it is worthy of mention since the chances of infection are greater with stabled stock and the disease resultingly harder to fight. In treating an aborting herd the first precaution to observe is to immediately burn or bury deeply the aborted calf and afterbirth and isolate the cow to prevent the spread of infection from these sources. It is a good plan also to remove a cow from the herd which shows symptoms of abortion until it is seen whether she is infected or not. As a precaution to prevent the spread of infection all the cattle in an aborting herd should receive at least one disinfection, and to do this properly the part of the herd which has been exposed should be disinfected first. As many of these cattle will be carrying calves the disinfection will consist simply in cleansing the outside parts thoroughly with a one in one-thousand corrosive sublimate solution or a three per cent creolin or lysol solution and flushing out the vagina with from one to two quarts of a one and one-half per cent of lysol or Creolin-Pearson solution. Four men with convenient chute and corrals can handle one hundred head in a day in this manner, with but little more trouble than dehorning. This disinfection will not destroy any germs in the uterus but will destroy any which are working their way in through the vagina from recent infection.

The bull should next be treated first by clipping the hair from around the sheath then disinfecting externally as before advised, and running a rubber tube or douche up the sheath and closing the opening of the sheath the fluid can be worked around by external mani-

pulation and a thorough disinfection accomplished. During the breeding season this should be done frequontly particularly if there is possibility of the bull's becoming infected. Five minutes time will do all the work necessary, the ugly animals even standing very quietly. The work is most easily done in the chute taking the next to the bottom board off the side to work through, and tying one of the animals hind legs back to prevent injury to the operator.

The method of treatment of aborting animals varies with the size of the herd. With small herds where only a few animals abort it is best to take an animal when it aborts and flush out at once, repeating about six times in ten days. With larger herds it is doubtless best to isolate the aborting animals in a pasture by themselves and when calving time is over disinfect all the aborting animals at one time. They should be disinfected at least six times and the womb thoroughly flushed out. In order to do this properly the right arm must be carefully introduced into the vagina and the tube or douche passed through the neck of the uterus into the womb. In disinfecting the uterus we use a weaker solution, one per cent, owing to the greater sensitiveness of the membrane. From one to two gallons is necessary for this flushing which should be thorough, the amount of fluid depending upon how recently the animal aborted; the uterus being more dilated if the abortion be recent. The same precautions are to be observed in disinfecting the external parts.

In handling the animals a chute such as is used in dehorning is very satisfactory. A platform can be erected over it and a barrel or tub containing the disinfecting solutions placed on top of that at an elevation of about ten feet above the cows back. The solution may be siphoned out and about fifteen feet of rubber tubing 5-16 inch in diameter is necessary. A uterine douche is a great convenience for this work such as is shown in cut. These instruments can be secured from Sharp & Smith, 92 Wabash ave., Chicago, or Haussmann & Dunn Co., 107 S. Clark st., Chicago, or from any veterinary instrument dealer at a cost of about $3. Special care should be exercised in the disinfection not to infect the healthy animals and hands and utensils of the operator should be thoroughly disinfected by washing with a three per cent solution of lysol or creolin.

In April and May the writer directed the disinfection of two herds near Bozeman. The owner of one herd of 125 head of range cattle said he considered the disinfection but little more work than dehorning and I was satisfied that four men with proper facilities could disinfect 100 of the animals which had been exposed or about 60 infected animals in a day. The owner of the other herd said he considered the disinfection so simple that he would in future disinfect his bull weekly during the breeding season. In the disinfection of these herds the conditions were met which will apply in general to all herds. The methods followed were exactly as advised in this bulletin and in actual use were found to be quite practical.

So-called Remedies and Treatment.

Owing to the peculiar character of this disease particularly with reference to affected animals becoming immune many have been misled in prescribing remedies which apparently had a beneficial effect but which happened to be administered just when the disease is on the decline. Manufacturers of quack remedies knowing the peculiarities of this disease following the wake of almost every attack of abortion and undertake to cure the aborting animals; as a result they reap a rich harvest for they give their medicine just when the trouble is over.

Fluid extract of Black Haw and carbolic acid have been recommended as valuable medicinal treatment for this disease but their reputation has been gained chiefly from the fact that they have been administered in a number of instances just when the disease was on the decline and as a result got undeserved credit. With reference to carbolic acid were it used in sufficient strength to kill the bacteria it would kill the animal and further carbolic acid is converted as soon as it enters the intestinal tract into a form called sulphophenic acid which is inert and has no effect upon bacteria. Carbolic acid can have but one beneficial influence and that is as an intestinal antiseptic, and considering the nature of the disease there is in all probability little opportunity for infection from the intestinal tract.

Disinfectants.

Corrosive sublimate or bi-chloride of mercury is put up in tablets

which can be obtained at any drug store with directions for making one in one-thousand solution. Usually one tablet to a quart or pint is the strength required.

Creolin-Pearson and lysol are used in preference to carbolic acid as disinfectants because they mix much more readily and thoroughly with water than does carbolic acid and in the proportions recommended, one and two parts to the hundred parts of water, make very complete mixtures either with cold or warm water. Warm water is to be preferred. Both are coal tar products and can be obtained from any drug store. Creolin-Pearson is specially recommended because of the fact that it is a definite chemical compound and does not contain many of the impurities which are found in the cruder and cheaper products. Lysol may be considered equally good and has the advantage of being a trifle cheaper.

Conclusion.

The treatment recommended may be modified in grade herds in which the cattle are worth as much for beef as for breeding. In this case the aborting animals had best be isolated and then fattened and beefed. Precautionary measures should then be taken with the remainder of the herd by treating as before advised. Particular care being taken to thoroughly and frequently disinfect the bulls. In this way the disease can be readily and cheaply stamped out by the second or third year. With better graded stock it will pay to disinfect both aborting and exposed animals and eradicate the disease as before described. In general the disease may be avoided by disinfection of newly purchased stock; by care to avoid purchasing breeding stock or bulls from aborting herds; by as far as possible keeping stock from aborting herds and by frequent disinfection of breeding bulls.

BULLETIN No. 50,

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

I Poultry Management.
II Poultry Diseases

Bozeman, Montana, October, 1903.

BOZEMAN REPUBLICAN—1903

MONTANA AGRICULTURAL

Experiment Station.

BOZEMAN, - MONTANA.

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Bozeman, Montana.

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Montana Experiment Station.

BULLETIN NO. 50. - - OCTOBER, 1903.

Poultry Management.

F. B. LINFIELD

Introduction

Poultry and poultry products because of the smallness of the individual producer, and also of the product, is thought by many to be an insignificant business, yet, because of the wide and universal demand, is one of the large industries of the country. The yearly value of the product of the American hen is close to $300,000,000, larger than any other one industry except the cow.

There is yet much room for the growth of the poultry industry in Montana, according to the statistics gathered by Mr. C. H. Edwards during the year of 1891. It would appear that about $1,500,000 worth of poultry and poultry products from outside the state found a market in Montana—about $5.00 for each person in the state.

To those not initiated, and to the person who handles a few fowls, no business seems so simple as that of handling poultry and yet few businesses have so many failures to record when started on a commercial scale. Much more knowledge, skill and careful management is needed, if success is to be attained, than many suppose. A person must know his flock and with patience watch them from day to day, and by proper methods of care and feeding maintain the birds in the best condition of health and vigor. To attain success with poultry a man must in a measure be a poultryman, he must have a liking for the business, and the patience that looks after every detail in the care of the birds, however small it may be.

My observation would lead me to the generalization that the organs concerned with maternity in animals are more economic producers of concentrated food products, possessing greater elasticity of

production and are capable of greater extention and development than any other construction forces in the body of the animal. This is illustrated in several directions. An old animal will not fatten as economically as a young one, but the old animal will grow a foetus as economically. The old animal again, will produce milk as economically as the young animal. The young animal retains much of the productive qualities of the maternal organs of the mother, and considering its weight, gains in live weight much faster and more economically than later in life. Poultry also illustrate this same general principle. In the production of eggs the maternal organs of the animals are concerned. A six pound hen of the laying strain will produce from 2 to 4 times her own weight in eggs in a year, and this she will do with about sixty pounds of dry matter in feed. A six pound hen on feed costing not to exceed 75c to 80c will produce from $2.50 to $3.00 worth of eggs at Montana prices—25c per dozen on the average.

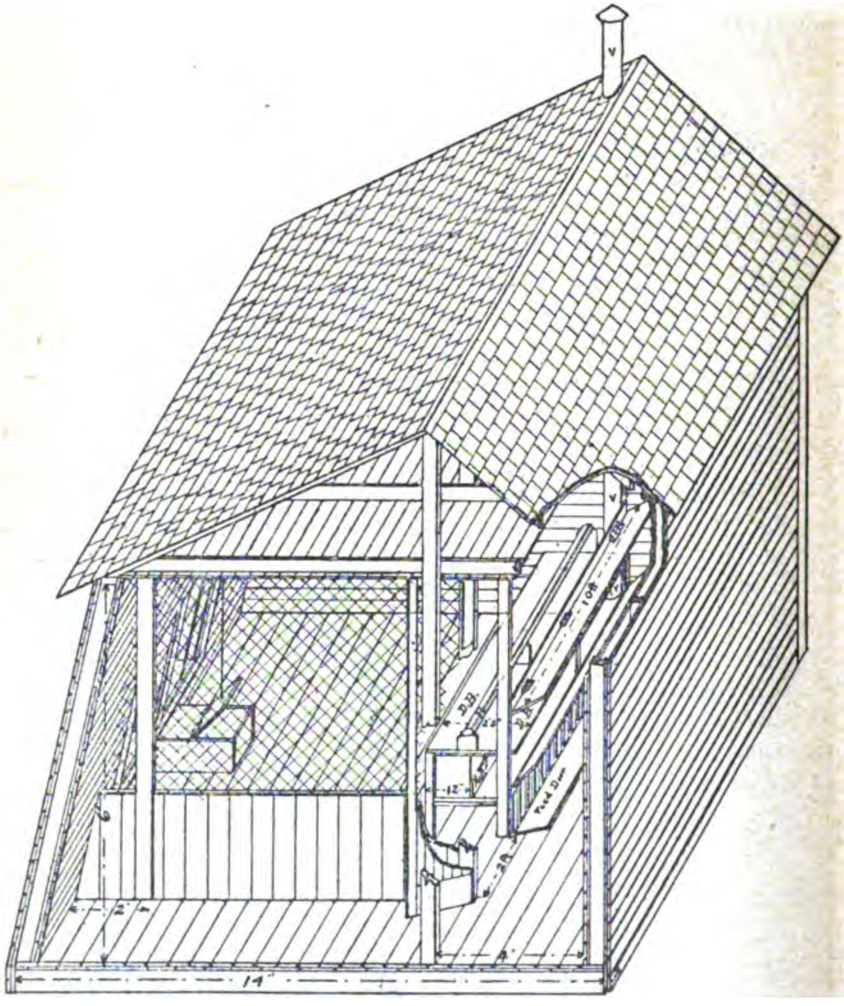
It is within comparatively recent times that attention has been paid to selecting poultry on the basis of egg records, but the result has shown that there is just as great room for increased production in this line as with milk production in the cow. Poultry, therefore, are among our most economic food producing animals. Again the prices offered in the state are such as should assure a very profitable market for the home producer.

Those who assay to obtain proficiency in the handling of poultry, however, should be students of poultry books and poultry papers. These record the experience of other men, their successes and their failures, experiences which will be of very great value to the beginner and not invaluable to the most experienced.

Success with poultry comes from so handling them as to avoid disease, rather than the ability to fight the disease when it appears important as this latter may be. It is for this reason that a few brief thoughts are added on the general treatment of fowls. Profits come from healthy fowls not from sick ones. It is very important, however, to recognize the disease when it does come, as come it may in the best managed flock, so that the loss may be reduced to a minimum and to enable us to treat the birds successfully and thus save a valuable flock for future usefulness.

The Poultry House

In the Montana climate, probably the first consideration should



BUILDING ON MONTANA STATE FARM.

be a good house. It need not be expensive, but it should be warm,

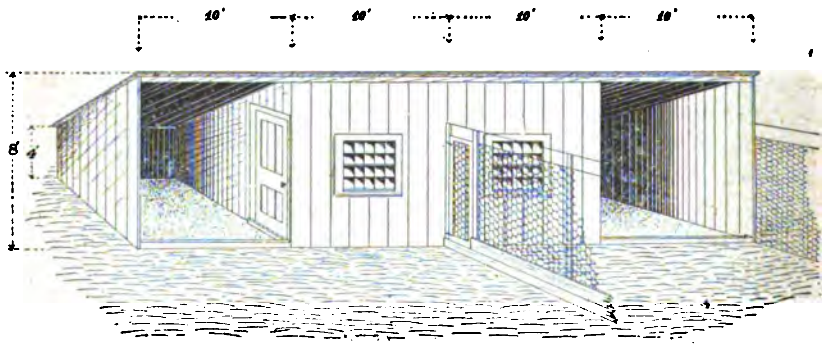
sunny and dry. Cheap lumber and building paper with plenty of window lights will give these requirements. In this connection I probably could not do better than describe the construction of the house used on the Station farm and also a house of a smaller size recommended by the Experiment Station of Utah.

FIG. 1. illustrates a model form of poultry building, and is with the exception of some slight details of the same construction as our main building. This house is 14 feet wide, pens 12 feet long with walls, roof, floor and windows constructed as previously described by the wall double boarded inside and out with tar paper between. The floor also double, and on the roof tar paper beneath the shingles. A four foot passage way runs throughout the rear. Access to the pens is through doors two feet wide, which open inward against a partition between the pens. This partition is matched stuff for 2 feet and then wire netting up to the ceiling. The arrangements of the roosts (R), the drop boards (D. B.), the nest boxes (N. B.) and the feed board are very simple. The fowls are fed their soft feed through the slatted front of the pen upon the hinged feed door, which when not in use, is hooked in a perpendicular position. These slats are three inches apart and fourteen inches high. Immediately above upon a platform 20 inches wide, the nest boxes are placed facing the passageway. Eggs are gathered from them by opening the hinged door in the passageway which extends in front of the platform. Nests are best made of ½ inch lumber, boxes 12x12x14 inches dimension. Above the nest boxes is another platform 22 inches wide which catches the droppings from the roosts. This drop board (D. B.) extends about 1½ inches into the passageway so that in cleaning the edge a pail may catch under it. The roosts are placed 6 inches above the drop boards and are 2x3½ inches with corners rounded off and the flat side up. (V) Ventilator is placed in the corner of the pen close to the passageway, and the damper is operated therefrom. The exit through the floor is surrounded by a box as shown. This is to prevent litter from falling through. The front wall is inclined inward two feet at the top in order to take greater advantage of the sunlight, and the building is sealed with matched flooring upon the lower side of the collar beam. Where it is intended to keep only 40 or 50 birds, a saving of space may be affected by running the

passageway through the center of the building from front to rear, mak ing two pens and arranging nest boxes, etc., on either side of the passage way, with the door on the north side and the ventilators on either side

Ventilation.

Proper ventilation is an important factor in the management of the poultry house, and the object should be to remove the foul air and retain the warmer and purer air without causing a draft. Our method of securing this result is simple. An ordinary stove-pipe with damper extends from a hood on the roof to within six inches of the floor. The The lighter and warmer air near the roof of the building warms the metal pipe which is a good conductor, which in turn warms the air inside causing it to rise slowly. As a result, the air flows into the pipe from the opening near the floor, this gradually removes the air in the immediate vicinity of the fowl. We have found this method an admirable one in our practice, performing the work excellently.



House on Utah Station Farm

"I give here a sketch of a poultry house that will answer most purposes. It will be suitable for the farm and also for the town lot, It can be extended to any length desired, or it may be cut in two where only a small number of fowls are to be kept. The dimensions given are for a house that will accomodate about fifty of the smaller breeds of fowls and about forty of the larger.

Dimensions.

"It is forty feet long and 10 feet wide, divided into two pens, each ten by twenty feet, ten feet of the closed part being for the roosting and laying apartment and ten feet open scratching shed. It is eight feet high at the front and four feet at the back. The outside yards should be about 20x100 feet each. There is no hallway, but there is a door entering from the open shed into the closed part. The partition between the two outside pens may be of wire netting but there should be about two feet of boards at the bottom to prevent the fowls fighting through the wire.

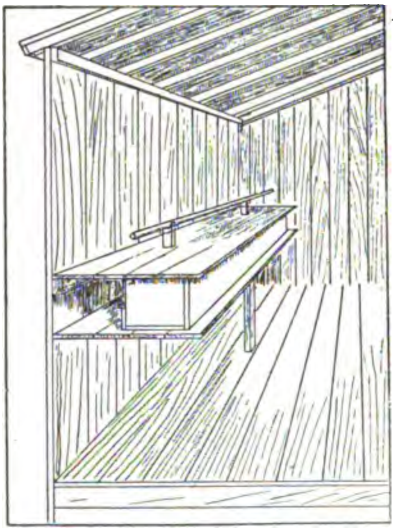
Materials

"The sills should be about 4x6. For framework and rafters use 2x4 stuff. On outside of studs nail good common lumber close together. On top of this tarred paper; then on top of this put on tongued and grooved lumber up and down. For the roof use common sheeting laid close together. On top of this place tarred paper, then shingles. Instead of shingles Neponsit Red Rope paper may be used. The door opening into the scratching shed should fit tightly and if necessary a storm door should be put on in winter to shut out cold and draught. The window should open into each of the closed pens. This should be about 24x24 inches, and it should be double in winter. It should be low enough down so that the sun in winter entering the the window will fall on the floor. The end walls of the scratching shed need not be double boarded and papered, but should be airtight.

"In the colder portions of the state it may be necessary to use another thickness of boards and paper in the closed pens. In that case another layer of paper can be put on the studs and tongued and grooved boards on top of that. But probably a better arrangement would be to nail sheeting on the studs and put Neponset Red Rope roofing on top of that. That makes a good lining. All lumber in the inside of the building should be planed. This makes it easier to keep the house free from vermin. Instead of lumber the walls of the closed pen may be made of brick with adobe lining. Some claim that this will be warmer and drier.

Nest Box

"One of the important things in the poultry house is the nest. To prevent egg-eating the box should be dark and shallow. The cut shows a good plan. It shows a roosting platform with a row of nests underneath. This plan is recommended by the Reliable Poultry Journal. If intended for Leghorns, or medium sized hens, nests 12x12 inches and 7 or 8 inches high will be about right. If for Brahamas or Cochins they should be about 15x15 and 10 inches high. Have some chaff or other good material in the bottom of the box so that there will be less danger of the eggs breaking, as a broken egg in the nest is al-



THE NEST BOX

most a sure way of teaching the hens to eat eggs. The bottom board of the nest shown in the illustration should be hinged to the wall of the poultry house so as to open upward. The upright which holds the bottom board in position is also on a hinge so it can be kicked from under the board to allow cleaning. The top board or roosting platform should be built on an incline and also hinged to the wall so it can be

raised to get at the eggs. The roosting pole should be about six inches above the platform and may be 1x3 inches, the hens sitting on the wide surface.

Storm Door

"For stormy weather there should be provided a storm door for the open shed. This may be made of oiled-canvass tacked on to a light frame and should be hinged at the top so that it can be hooked up to the ceiling when not needed."

Size of House and Pens

The size of poultry house usually recommended is one that will give about 6 to 8 square feet of floor space to each bird. Thus, a pen 10x12 feet will accomodate 15 to 20 birds.

The modern practice is not to allow the fowls the run of the farm except perhaps for a month or two in the fall after the crop is off, but to confine them in yards near the house. These yards or runs should afford 50 to 100 square feet of space for each bird. Part of the run should be planted to clover and grass. In part sunflowers may be planted for summer shade and fall feed, and part may be cultivated for a succession of green crops during the summer.

The Stock to Select

For satisfactory results, good birds are needed, and here as with other classes of livestock, pure breds and not cross-breds or scrubs are to be preferred, particularly on the side of the male. Again, get a good strain of the breed selected, a strain noted as large egg producers. Poultrymen are now gathering such data and breeding for a record.

The profit with poultry will in a large measure be influenced by the time the eggs are produced. During the late fall and winter months, fresh eggs command a fancy price. Young stock, the early hatched pullet, is the bird that under proper care will produce eggs at this season. Not alone is the young bird an early layer, but they also produce the largest number of eggs per year. As a rule the first two years are the profitable egg-producing years of the fowl's life. These birds should not be kept over the third winter except perhaps for the

purpose of producing eggs for hatching, if an extra fowl. This larger return from the young fowl many people seem to forget, yet it is a very important fact in poultry profits.

Comfortable Quarters

In the proper feeding and proper care of fowls is where perhaps most people fail. Fowls as a rule will not produce eggs if subjected to the continuous cold weather of winter. They must therefore be comfortably housed. There is danger here, however. During the day with the sun shining on the building, the house warms up and the warm air takes up much moisture. During the night, on the other hand the house cools off very much and may chill the birds. The cold air, moreover, not being able to hold as much moisture as the warm air, the moisture may condense in the house, making it damp. These extremes in temperature and also the consequent dampness frequently give rise to colds and may develop into roup of some form.

These extremes of temperature and the dampness may in a measure be avoided by thoroughly ventilating the house during the day, being careful, however, to avoid draughts, and then closing up the house at nights. If in addition to this a little heat is used in the house at night the result will be still better. It will not need much heat. just enough to prevent the house getting very cold, thus avoiding extremes.

This of course is artificial treatment but so is the production of eggs during the cold winter weather. To get the winter egg we must keep the fowls comfortable and healthy. The easiest and safest method to attain this may be by a little artificial heat during the winter. In a small house a small stove is the only practical method of heating and some form of the hot blast stove in which the draught can be thoroughly controlled and a small fire kept going for several hours. For a large poultry house, some form of small water heater is preferable as the heat may be more easily distributed over the building and more easily regulated.

The central thoughts are (1) that to produce eggs in winter a comfortable temperature for the fowls must be maintained and too great cold avoided; (2) that a fairly uniform temperature must be

maintained; (3) dampness must be avoided. There are probably other ways than those suggested to attain those objects.

Feeding Poultry

The matter of feeding while important is perhaps not as difficult to properly provide for as the matter of comfort and health. The weight of experience seems to show that a proper combination of hard feed, soft feed, green feed, meat scraps and grit give most satisfactory results.

In the morning give a warm mash, composed of bran and shorts and some ground grain. This should be mixed with water and seasoned slightly with salt and pepper. This mash may with advantage be wet and mixed with warm skim milk instead of water. The skim milk is valuable as a poultry food and can in a measure take the place of meat scraps or other animal food. Do not give a full feed of this but after it is eaten up clean, scatter some grain in the litter on the floor, for the hens to scratch around and gather up. The grain should vary from wheat and oats to peas or corn, if available, to give variety. About the middle of the afternoon or a little later give a feed of wheat also scattered in the latter on the floor, all that the birds will eat up before roosting time. This method of feeding forces the fowls to keep busy and gives them exercise which is needed for healthfulness when confined in pens. Give cut bones and meat scraps three times a week. In the winter keep a little green feed available for the fowls all the time, a head of cabbage hung up in the pen and at other times a mangle or sugar beet and again a little lucern or clover leaves will add variety. In the summer if the runs are large, part of them may be seeded to clover or alfalfa. or a little rye may be sown as a variety.

Fowls need grit to grind their food. Having no teeth the food must be ground in a special organ, the gizzard. Again, grit is needed to give material for the egg shell.

Bones provide a certain amount of animal food and also grit for shell material. Bones and meat scraps are usually inexpensive, but take some work and trouble to prepare as they have to be ground. Their place may be taken by oyster shells, ground bone and dried blood. The first cost of these is greater but they require little or no prepar-

ation before feeding. In the summer when the fowls have the use of a large run and especially if part of it is cultivated, less grit and animal food have to be provided, and if later in the season, for a month or so, they have the run of the fields they will be able to gather sufficient of both.

Fresh water should also be available for the fowls at all times.

Cleanliness and freedom from vermin are essential points in poultry profits. The poultry house should be whitewashed, using freely slaked lime, at least twice a year, the roosts should be frequently cleaned off and the litter cleaned out and replaced once a month or oftener. The birds will keep their bodies free of vermin if they have ready access to a dust bath. The roosts and nests should have an occasional wash of coal-oil to keep those pests in check.

Poultry Diseases Common in Montana.

BY H. C. GARDINER.

Introduction

Diseases in poultry are in general not effectively treated in the diseased individual, because of the fact that the trouble and time necessary for treatment more than equal the value of the individual bird. On the other hand an understanding of the different diseases with their predisposing causes is very essential in order to avoid loss and keep the flock free from disease.

In general it may be said that fowls properly fed, properly housed, and intelligently handled will keep in a vigorours healthy condition. In our experience at the Station the slight occasional loss of probably seven or eight birds in four years has been directly due to some error or oversight in care or feeding.

Diseases may be said in general to result from two conditions, one in which unfavorable surroundings, feed, etc., produce the conditions and on the other hand direct infection from some infectious or contagious disease. It is probably wise to point out at this time that the second source is most active when the fowls are in low condition as a result of improper feed and care.

Roup

Roup is undoubtedly the cause of more fatalities in the mature flocks of the North-western states than any other disease. It is generally prevalent in Montana and in certain localities is causing severe loss during the winter months.

During the past four years a thorough investigation of this disease has been carried out by the Bacteriological department at the Ontario

Agricultural College and the results of these investigations published in Bulletin 125 of that Station. The following notes on the disease are taken from that source.

The disease is infectious and due to a bacillus (B. cacosmus). It is prevalent in fowls kept in filthy, damp, draughty and poorly ventilated quarters. Vigorous stock in good surroundings prove quite resistant to the disease. Young fowls and those of the more delicate breeds are much predisposed to the disease.

Symptoms

The earliest symptoms is a putrid catarrh of the nostrils, followed by a dumpish condition during the earlier stages; and in the less severe forms of the disease the fowl retains its appetite. In some instances the face becomes swollen, birds manifest loss of appetite, becoming emaciated, and lie down and die in a few days. During the latter stages of this disease, diarrhoea with offensive yellow or green discharges hasten the fatal termination of this disease. To quote Bulletin No. 125, Ontario Agricultural College. "In the first stages of roup the birds often cough or sneeze and the breathing is noisy, caused by the partial closing of the air-passages which become blocked with the discharge from the nostrils. When the air passages become entirely closed by the discharged products, the fowl has to open its beak in order to breath. Sometimes a yellowish cheese-like mass forms in the nostrils, if this mass is removed, an uneven bleeding surface is left, which form a new cheesy mass in from 24 to 48 hours."

These cheesy masses sometimes grow in the eyes and in the ducts between the eye and nostril and sometimes form in small tumors under the skin of the face. "The secretion from the eyes is similiar to that described as coming from the nostrils, i.e., at first a clear liquid, then changing to a putrid grey and offensive discharge. If the secretion is retained in the eye socket, it undergoes a change, becoming a yellowish, solid, cheesy mass of the same appearance as the nasal tumor. This cheesy mass either forces the eye out of its socket or the inflamation entirely destroys it.

Combined with the symptoms of roup above described, there are often patches of a greyish, yellow exudation firmly adherent to

the mouth, throat, etc. These patches are called false membranes. At one or several places in the mouth and throat, these yellowish, smooth or uneven membranes appear, and either remain small and disappear after a few days, or grow thicker, spread, and become firmly attached to the mucous membrane, and if they (the false membranes) are removed, an uneven, bleeding surface is exposed.

When the throat is blocked by these false membranes, the animal's breathing becomes abnormal, and the air passing through the throat produces loud noises. Gradually the visible mucous membrane and the comb turn blue, and the fowl generally dies from suffocation.

Treatment

Care taken to avoid infection as outlined in the causes, which predispose toward this disease, isolation of infected birds and disinfection of poultry houses and runs immediately adjacent, with a 3 per cent. creolin solution constitute the treatment, under average circumstances. If particularly desired to save some valuable individual. immersing the head in a 1 to 2 per cent. permanganate of potash solution is a method of treatment giving valuable results. "Fowls are treated in the following manner: The nostrils are pressed together between thumb and forefinger in the direction of the beak several times. Pressure should also be applied between the nostrils and eyes in an upward direction. This massage helps to loosen the discharge in the nostrils and eyes. The bird's head is then plunged in a potassium permangnate solution for 20 or 30 seconds, in fact the head may be kept under the solution as long as the bird can tolerate it. The treatment should be given twice a day until all symptoms have disappeared."

In conclusion our authority says: "The most effective preventative for roup is to keep fowls in good, sanitary condition in dry, roomy yards, and dry, clean, airy houses which are free from draughts and can easily be cleaned and disinfected."

Catarrh

Catarrh in poultry closely resembles the common "cold in the head" of man. It is accompanied by sneezing, difficult breathing,

watery discharge of nostrils, in later stages becoming thick and glutinous.

The causes producing this disease are lack of ventilation of houses, draughts, dampness, cold winds, exposure, improper care and feeding The prevention consists in the removal of such conditions, and when birds become affected, Douglas mixture in the drinking water acts as a splendid tonic. In addition the following powder may be given in the food: Gentian, 1 ounce; ginger, 1 ounce; capsicum, ½ ounce; iron sulphate, ½ ounce; hyposulpate of soda, ¼ ounce; a teaspoonfull to 15 fowls being about the right proportion. Douglas mixture is a splendid tonic to give during the fall, winter and spring months and we have found with its occasional use, sickness is a very rare occurrence.

Douglas mixture consists of: Sulphuric Acid, 1 ounce; iron sulphate, 3 ounce; water, 2 gallons; a teaspoonful to a pint of drinking water is sufficient. We have made it a practice to give it once a week in the drinking water, and where there were any signs of disease used it in drinking water daily.

Gapes

The gape worm is causing loss among flocks in some sections of Montana and with the growth of poultry raising will give serious trouble in the future unless steps are taken to suppress this parasite

It is a small reddish colored worm which infests the trachea (windpipe) of young chickens and gets its nourishment by sucking blood from the wall of the windpipe, where it causes much irritation, and may occasion inflamation and suffocation. The male worm is about 1-5th of an inch in length and the female ½ inch. They are usually found attached in pairs to the windpipe. This infection occurs as a result of swallowing embryo worms or eggs in drinking water or in the food. A single infection is however all that is necessary as the worms reproduce in the body of their host. This practice secures most of its victims among the smaller and weaker chickens as they most easily become exhausted and suffocated.

Syomptoms

The disease chiefly affects chicks from 1 to 4 weeks old and may be detected by the dumpish condition of the birds, by gaping frequent-

ly with the head extended. Later a cough is noticed and a wheezing sound accompanies the breath, with gaping at frequent intervals. While coughing the chicks frequently dispel the parasites, which may be detected in the mucous which accompanies the coughing. As the disease advances the chicks become emaciated and week, wings hang down, gaping and shaking of head are frequent, and at last death from suffocation and exhaustion intervenes. The stronger birds and those infested with a few worms, only evidence a slight inconvenience and soon shake off the effects of the disease.

Treatment

Individual cases may be relieved by removing the worms from the windpipe with the end of a feather or a loop of horse hair, and excellent results may be obtained by dropping one or two drops of salicylate of soda in the wind pipe.

General treatment consists in the prevention of the spread of infection. by isolating the affected birds, frequent disinfection of their yards with 5 per cent solution of crube carbolic acid, disinfection of drinking and feeding troughs with boiling water, and exerting every percaution to prevent the contaminating of their food or drink. The bodies of dead birds should be burned and where possible healthy birds should be changed to new runs until the old runs were thoroughly disinfected.

Lice

The large grey louse (Liperiris caponis), the red mite (Dermaceysses gallinae), the bird flea, and the mite (Sarcoptes muteces) causing scaly legs, are the external pests causing the bulk of the trouble arising from the insect pests.

Cleanliness is the starting point of success in combatting these pests, and houses and fixtures of simple construction, affording few cracks aid materially in preventing attacks, as they do not afford the protection necessary for the lice.

In keeping buildings free from lice, kerosene must be used freely on roosts, nest boxes and other fixtures, accumulations of filth are to be avoided in every direction, and all surfaces on the inside of the building should receive a coating of white-wash containing carbolic acid at

least twice a year. The efficiency of this white-wash is greatly increased if applied with spray. Litter on the floor of pens and in the nest boxes should be renewed frequently and insect powder scattered in the nests. Kerosene emulsion is valuable particularly for the flees and mites and is best applied with a spray pump and made as follows: Kerosene, 1 gallons; water, 1 gallon, soap, ½ pound. Dissolve the soap in the water by boiling, and while hot turn in the kerosene and churn briskly for 5 minutes. This solution is sufficient for about 15 gallons of spray solution. Six ounces of crude carbolic acid to the gallon of water (hot) also makes a very good solution to use as a wash for roosts, nest boxes or floors, when cleaning out.

The largest number of deaths from these pests occurs from the large grey louse which attacks young chicks. These lice are found on almost all chicks which have been hatched under hens and annually kill thousands of young chicks. It is a good practice to grease lightly the back of the head and under the wings on all young chicks which are hen hatched, the lice confining themselves almost entirely to those parts. Common lard serves the purpose but we have used carbolated vaseline and find it preferable.

The red mite is combated more effectually with kerosene applied to the hiding places, by the use of insect powder on the fowls and by providing opportunities for dusting

The mite causing scaly leg is a particularly annoying pest and very prevalent. It barrows under the scales on the legs and by its irritation causes an exudation of which the enlarged scaly portion is formed. The heavier breeds of fowl are most affected by this pest, the Mediterranean classes apparently resisting its attack to a marked extent.

In order to avoid the spread of this disease it is well to isolate affected birds when treating them in order to prevent the infection of the rest of the flock. In order to reach the parasite it is necessary to soak off the scaly crust with warm soapy water and then carefully remove to avoid bleeding. The legs should then be moistened daily for three or four days with balsam of Peru or 10 per cent. creolin ointment.

BULLETIN NO. 51.

MONTANA

AGRICULTURAL

EXPERIMENT STATION

—OF—

THE AGRICULTURAL COLLEGE OF MONTANA.

First Annual Report of the State Entomologist of Montana.

BOZEMAN, MONTANA, DECEMBER, 1903.

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Montana Agricultural Experiment Station,

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Notice.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

THE COMMON TOAD

(See Article in this Bulletin)

Montana Experiment Station.

BULLETIN 51. **DECEMBER, 1903.**

INTRODUCTION.

This first Report of the State Entomologist of Montana contains an account of a few of the most important insect pests of Montana and in addition, a fairly complete, though condensed, manual of insect pests. This manual is intended to put in easily accessible form the most important information regarding a large number of insects now in the state or liable to be introduced.

Considering the great importance of the codling moth, the reader will perhaps expect to find an account of it in this report. However, such an account is omitted for two reasons, first, a report on this pest was issued from the Experiment Station a few months ago, copies of which are still available for distribution, and, second, it is intended to conduct further investigations on this pest during the coming summer (1904) and we shall desire to publish those results one year from now. In view of the fact that the codling moth will for years to come be the most important insect pest with which Montana apple growers will have to contend, it is our intention to make the next report upon the subject the most complete and practical that has yet been issued from this Station.

In view of the great economic importance of grasshoppers and because of the unusual demand for information concerning them, we have given them prominence in this report.

We renew our statement of willingness to answer inquiry regarding insect pests. Such requests for information should always be accompanied by specimens of the insects that are doing the damage and a statement of the facts necessary for our information in making recommendations.

Every vegetable product of the soil is subject to the attack in insect life and every crop that is grown by men is more or less in-

jured by insect pests. These injuries may be so conspicuous as to force themselves upon our notice or they may be so hidden and insidious as to escape detection except by the most observant. The farmer may suffer heavy financial loss, or because of the higher price which comes as a result of a shortness in the crop, he may be only slightly affected. In the latter case the general public become the suffers, but in all cases, losses through depredations of insects come out of the coffers of man, if not out of his daily bread.

Considering the great agricultural possibilities of this state, together with the fact that, incidental to commercial practices, injurious insects new to this region are constantly liable to introduction, it is very important that every possible means be imployed to prevent the introduction and spread of pests of all horticultural and agricultural plants.

All rational means of defense against injuries from animals of this class are based on a more or less intimate knowledge of the life history and habits of the insects. It is apparent, therefore, that as a defensive measure the acquiring of a knowledge of life histories of the insect destroyers of our crops is of great practical value and must always precede quarantine and medical work.

Again, in order that investigations may be safeguarded against danger of becoming narrow and losing their practical setting, it is obviously necessary that they be conducted not only in the entomologist's office or in one locality, but in the field and throughout the state.

Realizing the truth of these statements the Entomological Department of the Experiment Station is centralizing its efforts on the accumulation of information regarding species of insects that are now or may become injurious and, obedient to the Act of the Eighth Legislative Assembly, whereby the office of State Entomologist was created, is making its observations and conducting its experiments in all parts of the state.

THE BUD MOTH.

Tmetocera ocellana Schrif.

The bud moth was first discovered in this country in 1841 in Massachusetts and was at that time doing considerable damage. In 1869 it was pronounced the most injurious enemy of the apple tree, next to the canker-worm, in the state of Massachusetts. Since that time it has been spreading westward and has at times been very destructive, notably in 1891 throughout Massachusetts, New York and Canada and again in Michigan in 1892. It now occurs throughout Northern United States from the Atlantic to the Pacific ocean but is much more thoroughly distributed in the east than in the west. It has been found as far south as Washington, D. C.

For fully fifty years previous to the time the insect was first detected in Massachusetts it was a well known and destructive species in Europe. There can be little doubt that it was introduced into America from Europe on young trees, intended for planting.

OCCURRENCE IN MONTANA.

While engaged in certain investigations concerning the codling moth in Missoula in the spring of 1902 the writer's attention was called to trees in the home orchards on Front street, Missoula, the foliage of which showed distinct signs of injury by insects. On examination it was found that the injury was caused by the bud moth. The vernal form of the larva was doing rather serious damage on many trees. The buds, both leaf and flower, were severely injured and a large proportion of the expanding clusters of leaves were tied together, each containing one of more nearly full-grown larvae which were feeding voraciously. Beside occurring throughout Missoula and in the orchards just outside of the city, the insect is also gaining a foothold for a considerable distance up the valley of the Bitter Root river.

IMPORTANCE OF THE PEST.

To just what extent this insect will be destructive in Montana's climate, if it becomes generally distributed, cannot be foretold. Ex-

perience of other localities has distinctly shown that its injuries will be more severe some years than others. For the present, at least, Montana fruitgrowers should look upon it as a pest of first-class importance. They should inform themselves concerning the habits and appearance of the insect in all its stages and should be on the lookout for it in the orchard.

Spraying does not appear to be effective in killing the larvae Should the moth be admitted to the nurseries of the state it would be very unfortunate not only for the nursery men but also for the persons who purchase trees from them.

NATURAL HISTORY AND HABITS.

The larva or so-called worm spends the winter in a temporary cocoon or hibernaculum on the trees. These hibernacula are remarkable objects in that they so closely resemble the bark and the felty surface of the young twigs as to be very difficult of detection even by a trained eye. They are closely secreted in crevices around the buds or in the depressed scars that mark the spots where leaves were attached. They are about one-sixteenth of an inch across and though made principally of the silken secretion that is produced from the silk organs of the mouth of the caterpillar, they contain enough of the surface parts of the surrounding bark to make them very inconspicuous.

Besides occurring on the twigs as has been described by various authors, the writer has found them also under the scales of bark in association with the hibernating larvae of the codling moth.

In the spring of the year at about the time the buds are swelling, the larvae, which are dark brown with black heads, emerge from their winter quarters and crawl to the buds. Observation is lacking in Montana as to the precise time, compared to the opening of the buds, that they arrive. It is probable, however, that in this respect the habits would not vary much between here and other climates, for the same conditions of weather revive both insect and plant life. Without much doubt, while a few larvae arrive early enough to make it necessary for them to bore into unexpanded buds in order to get food, the majority of them reach the buds after they have begun to open. In both cases, alike, the larvae, which at this time

are less than a quarter ot an inch in length, go at once to the tender, inner part of the bud, where they teed on the tender parts and do great injury, often destroying the terminal growing portion of the twig. If the bud be a fruit bud it likewise is destroyed, thereby preventing the possibility of the production of fruit.

The destruction of the terminal bud prevents the further elongation of the twig and at the same time causes some lateral bud to grow into a principal stem. While in some cases such an unatural growth is not a disadvantage, in many cases the result is a very undesirable shape of tree. This is particularly true of young trees in the nursery row.

The larva soon makes use of one of the more advanced leaves in the construction of a tubular retreat, which constitutes its home and from which it emerges from time to time to feed. In feeding, it draws in other leaves and fastens them together into a sort of nest which is very characteristic of the species. Some of the leaves become detached, but being bound to the other leaves fail to drop to the ground, thereby making the nest all the more conspicuous, because of the brown leaves among the green. A badly infested tree therefore has a decidedly unnatural appearance.

The larvae continue to feed in these nests until they reach full growth, when they construct cocoons in which the remarkable change from the larva to the pupa and from the pupa to the moth is to take place. The full grown larva is a half inch in length, nearly naked and of a brown color with glossy black head and shield just behind the head. See plate I, (figure 7).

The cocoon is constructed, in many cases, in the tubular retreat occupied by the larva. The walls are thickened and the ends closed up, thereby preventing the entrance of parasites, while the moth lies in the defenseless pupa stage. Other cocoons are made at any convenient place. Sometimes they occur in a fold of an otherwise uninjured leaf.

In due time, oı about two weeks from the time the larva changed to a pupa, the moth appears. The pupa works its way out of the end of the cocoon, aided by the hook on its back, and the anterior end splits, thus setting free the moth, which crawls out, expands and dries its wings and flies away. In Missoula the moths

appear from about the first to the twenty-fifth of July.

The moths are most active during the night, remaining quiet during the day on the bark of the tree, which they closely mimic. They are also found to some extent during the day in the foliage. The cage erected in Missoula in the spring of 1902 for the purpose of facilitating the study of the habits of the codling moth, has afforded us also an opportunity for the close study of the bud moth. The bud moth was very abundant in this cage in 1903 and destroyed practically all the fruit buds, interfering seriously with our investigations of the codling moth. When disturbed or frightened the moths often flew directly away from the tree and coming in contact with wire netting clung quietly to it for a few moments. In a few moments, however, they flew back to the tree. It is plain that they did not feel safe on the netting and they would not have been safe were it not for the fact that no birds could reach them on the inside of the cage. In flying at such times the moth pursues an irregular zig-zag course and comes immediately at rest on lighting.

It is worthy of special notice that there is a close resemblance between adults of the bud moth and of the codling moth. An experienced person need have no difficulty in distinguishing between the two if he has before him fresh specimens, but when the scales of the wings are rubbed off as they often are in specimens captured in the orchard, separating the two at sight is not so easily done. When once placed on his guard, however, a trained observer is not liable to make a mistake. On the other hand there are many less important small moths in the orchard which the untrained observer or the person who has paid little attention to insect life may mistake for both of these orchard pests.

In a few days after emerging the moth begins to deposit eggs. We had no difficulty in finding quantities of them in the cage at Missoula and they were invariably on the smooth upper surface of the leaves. Other writers have stated that the eggs are laid singly or in clusters and on page 61 of Prof. Slingerland's bulletin on this insect (No. 107, Corn. Univ. Agric. Exp. Sta. 1896), is given a figure of a group of these eggs numbering about six, but our observation shows plainly that in Montana the eggs are laid singly. We have never found

more than two together. A single egg is shown at plate I (figure 1). They are usually oval in outline, some being circular or nearly so, and they measure slightly over one mm. in length, including the flat outer rim by which they are attached to the leaf. They are translucent and almost colorless at first, but as the embryo develops the black head and thoracic shield of the larva show through and the outline of the curled larva may be distinctly seen. The egg shell reflects the prismatic colors, both before and after the larva emerges.

We have above called attention to the close resemblance between the adult of the bud moth and that of the codling moth. It is even more difficult to distinguish between the eggs of the two species. In size, shape and general appearance, they are very similar. They are laid in precisely the same position on the foliage and are deposited at the same time. They both reflect light and show irridescence alike, and both are translucent. I know of no way to distinguish between the two except by the difference in the character of the surface of the shell of the egg.

The hatching of the egg takes place in from six to ten days after being laid, and, issuing from the egg, the larva makes a hole through the edge of the central portion and crawls forth. This caterpillar is greenish in color, very small and delicate and it at once sets about making a place of retreat and protection. Passing to the under side of the leaf it constructs a very small silken tube near the mid rib and usually towards the base of the leaf. The larva feeds from the epidermis and middle layers of cells leaving the opposite epidermis unbroken. The castings of the larva are built into the tube giving it a black color. The portion of the leaf from which the larva feeds is covered with silken threads laid down by the larva and whenever possible a near-by leaf is drawn up and fastened to the first leaf by the silken threads. Thus one often finds two leaves stuck together, and, in pulling them apart, finds the little black tube of this insect. The larva will not be seen unless forced to crawl out.

In selecting a place in which to construct ~~a~~ home the larva searches for two leaves that are near enough together to be easily brought in contact.

In the manner here indicated the larvae continues to feed until some time in September, when, apparently prompted by instinct they

crawl to the twigs, spin the temporary cocoons which they occupy during the winter months, and from which they issue in the spring and pass to the buds as previously stated.

THE KINDS OF TREES THE BUD MOTH ATTACKS.

While this insect is best known as an apple pest, it feeds also on pear, plum, quince, peach and cherry trees and on blackberry bushes, in all cases feeding on the buds.

MEANS OF DISTRIBUTION.

The manner of hibernation of the insect makes it very easy for it to be distributed on nursery stock, and this is doubtless the way in which it has become so widely distributed. It may be readily distributed on scions.

The moths are capable of flying and doubtless go from tree to tree and from orchard to orchard but they can only spread slowly in this way.

NATURAL ENEMIES.

It is very probable that many of these insects fall a prey to the birds that frequent the orchards. In fact it is reported that birds sometimes eat the moths. There can be little doubt that the Oregon chickadee, that is so common in the orchards searching on the trees for food, does much good in destroying these insects. Various other birds probably eat them in Montana.

It was very noticeable that the tree which had been inclosed in the cage in Missoula for one year was much more seriously affected by this insect. Birds had, of course, been excluded.

A number of parasites have been taken from the bud moth in the United States and in Europe but just how much good they do cannot be stated. I have reared an undetermined species from specimens of this pest brought from Missoula to Bozeman for study.

METHOD OF PREVENTING ITS RAVAGES.

In the East this insect is said to be a very difficult one to control. Just why this is so has never been fully explained, and as yet we lack a sufficient knowledge of the habits to enable us

to state definitely the cause of the failure of remedial treatment, but there is some reason to believe that in Montana a large majority of the larvae arrive after the buds have opened enough to allow them to crawl into the narrow cracks between the expanding leaves. It is instinctive with these larvae to get out of sight as soon as possible, and once inside the opening buds with a few leaves tied together into a nest, sufficient food for the remainder of the larval life is protected in such a way as to make it difficult, if not impossible, to get the poison in contact with the food.

If on arriving at the bud, the larvae finds its sufficiently open to allow it to crawl in, in all probability very little food is taken from the surface parts. If, on the other hand the bud is still closed, more or less of the surface is eaten in boring to the center. If the part of the bud through which the larvae eats its way is coated with a poison, a fatal dose may be taken but at this season of the year the buds are very rapidly swelling and a bud that is well coated one day may two days later, on account of the expansion of the surface parts, be so insufficiently covered as to be harmless to the larva that enters it. As is well known to all fruit growers, some trees expand their leaves earlier than others, and again peach buds open before most apple buds.

Again, after the bud may be said to be fully expanded the inner terminal growing shoot continues to put forth new leaves. These leaves are the ones that form the food of the larvae and they expand within the nest where they are not easily reached with a spray.

Considering how admirably the insect is protected by nature and its own habits, its control when in its spring nest is at least uncertain.

The problem is less perplexing when only nursery trees or trees in a young orchard are concerned. Under such circumstances hand picking of the nests should be very satisfactory. In picking the nests, however, care should be taken not to allow the larvae to escape to the ground for they would probably return to the trees. A pail, not a basket, shold be used in gathering the nests, which should be burned or thoroughly saturated with kereosene oil. If left in a pile at the side of the field, the chances are that some of the larvae would complete their development to the moth and fly to the trees.

There seems to be some promise of good results from the use of summer sprays applied at the time the eggs are hatching. As is indicated on a previous page, the very young larva on hatching from the egg passes to the under side of some leaf where it spins a delicate tube from the end of which it issues for getting its food which it takes from the surface parts of the leaf. If this part of the leaf be coated with a poison, the treatment should be successful. It would be necessary to get the coating on before the larva spins its web on the surface. The spray should be directed against the under side of the leaves.

For this purpose we recommend the use of arsenate of lead in preference to Paris green on account of the much greater adhesive quality of the former insecticide. Arsenate of lead sticks to the foliage through severe rain storms and when applied in the spring may be found still adhering in the fall giving a whitish color to the leaves. For this reason it has a particular advantage in the treatment of the newly hatched larvae of the bud moth.

In controlling the insect we recommend the following:

(1). Pick by hand and destroy the nests on nursery and young orchard trees.

(2). Spray thoroughly with arsenate of lead in the spring of the year just as the buds are expanding.

3). Spray thoroughly with arsenate of lead about June 15.. Give particular attention to coating the under surface of the foliage.

CONCLUSION.

This is a serious insect pest and one that the fruit grower would do well to become familiar with and suppress before it takes possession of his orchard.

THE OYSTER-SHELL BARK-LOUSE.

Lepidosaphes ulmi (Linn.)

This widely known injurious species is the only scale insect of importance to the fruitgrower that, so far as is known to the writer, has been recognized in Montana. It appears to be generally distributed in the state, particularly west of the main divide, where in some cases it has proved to be a serious enemy to apple trees. One orchard of 800 trees in the Bitter Root valley is so badly infested as to show its sickly condition at a considerable distance. Nearly every smaller limb and twig on the greater number of the trees is thickly incrusted.

There can be little doubt that this scale insect, which was known in Europe upward of a century ago, was imported into America on nursery stock by the early settlers and later transferred to Montana from other parts of the United States in the same way.

FOOD PLANTS.

The oyster-shell bark-louse has been recorded on a large number of food plants, the total number for America being about forty. The list included, beside apple and pear, various other fruits and practically all the more important shade trees of northern United States.

Dr. Howard has suggested that eventually two species instead of one may be found in the series in the list of food plants.

LIFE HISTORY AND HABITS.

If during the winter one of the female scales be turned over it will be found to contain a mass of very minute yellowish-white eggs, and in the pointed anterior end of the scale, the shrivelled body of the female. Dr. Howard has found the eggs under each scale to vary in number from 42 to 86.

In the New England states these eggs hatch about the first of June, varying in different years according to the forwardness of the season.. We have had but little opportunity to make observation on this point in Montana, and have but one record. On June 5, 1903, none of the eggs had hatched at Lo Lo. The young (Fig 3, c.) are able to walk immediately after hatching, and working their way out

from under the protecting cover of the parent scale they crawl to other parts of the twigs, principally to the young shoots which at that time of year are tender and succulent. In rare cases they settle on the fruit of the apple and pear.

After settling down and inserting into the bark the long thread-like hairs through which the juices of the plant are extracted, the

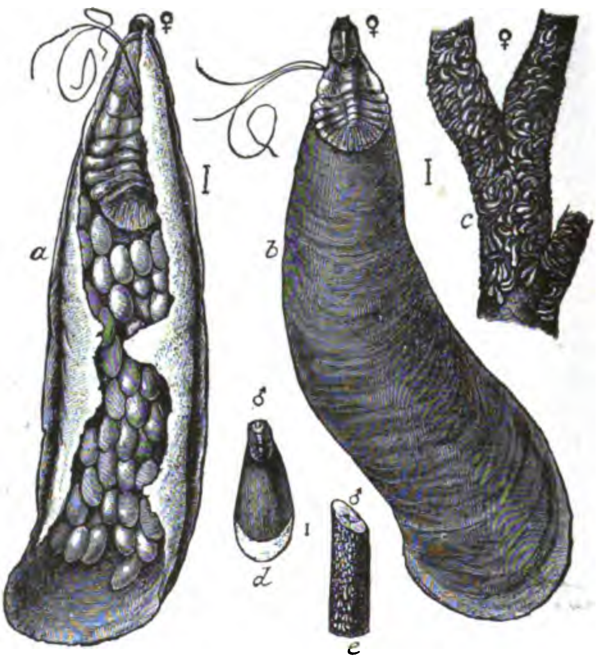


Figure 2.—Oyster-shell Bark-louse- a, female scale from below showing eggs; b, same from above, greatly enlarged; c, female scales; d, male scales enlarged; e, male scales natural size. (Howard, Yearbook, U. S. Dept. of Agr.)

insect goes through remarkable changes. From pores in the back, principally at the hinder part of the body, a glandular secretion appears, and from it the scale is formed. The female molts or casts the outer skin twice and the male once. The cast skins are incorporated in the scales (See Fig. 2, b). After molting both sexes continue to grow, the female attaining a much larger size than the male; com-

pare b. and d. of Fig. 2 The scales indicate approximately the comparative sizes of the insects under them. The mature male and female are very dissimilar in appearance. The male has long anternae, a pair of eyes, three pairs of legs, one pair of wings and at the end of the abdomen a long sharp-pointed organ. The female has no antennae, eyes, legs or wings, these parts all being lost in the first molt. When mature, the body of the female reaches to the posterior end of the scale, but as the eggs are laid the body shrinks and becomes shortened and when the full number of eggs has been laid it may be found lifeless, at the anterior end, the cavity under the scale now being occupied with the eggs. As previously stated, in this condition the insect passes the winter. The adult male and female are shown at Fig. 3.

In the northern part of the United States there is only one annual generation but in the South there are two.

REMEDY.

Insects of this character, covered as they are by a scale that fits closely to the bark, are not easily killed by contact insecticides. The most vulnerable point in their life appears to be just at the time the young are hatching and settling on the bark. We have previously recommended the use of kerosene emulsion as a remedy for this insect, in the strength of one part to nine of water. Various reports to the effect that this treatment has not been effective in Montana, have come to this office, but inquiry has shown that in all these cases there is no certainty that the application was made at the correct time. We can do no better than to repeat our previous recommendation to watch closely for the hatching of the eggs about the first of June and spray with with kerosene to the strength above mentioned, after the young have hatched. If, after a few days, more living lice are found the treatment may be repeated.

EXPERIMENTS WITH LIME, SULPHUR AND SALT WASH AS A REMEDY.

We take this opportunity to present the results of experiments conducted at Lo Lo, Montana, in the early spring of 1903, for the

puropse of determining the value or non-value of the lime, sulphur and salt wash, and certain modifications of the wash, as a means of destroying the eggs of this scale insect.

The experiments were conducted in the apple orchard of Mr. Delaney. At the time, pear buds were swollen almost to the point of expanding their first leaves and apple buds were slightly swollen.

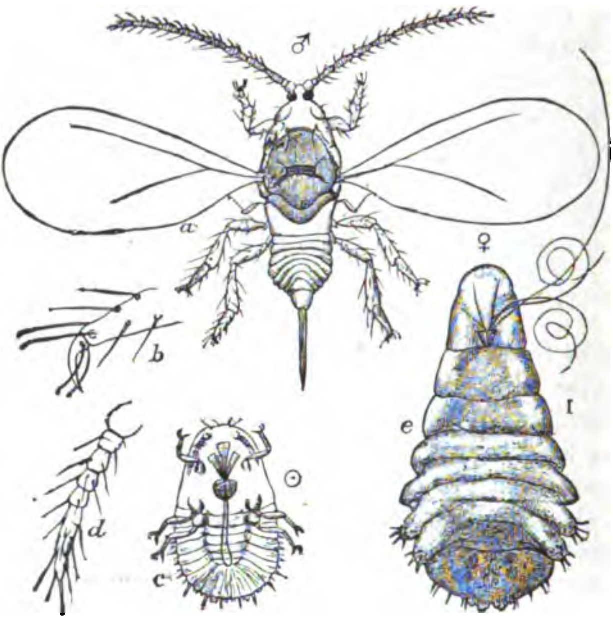


Figure 3. Oyster-shell Bark-louse; a. adult male; b, foot of same; c, young larve; d, antenna of same; e, adult female taken from scale: a, c, e, greatly enlarged; b. d, more enlarged. (Howard, Yearbook, U. S. Dept. of Agr.)

The trees are large and were badly infested with this insect. Seven to nine trees were used in each experiment, each lot being sprayed with a different mixture, but the total number of trees used constituted but a small proportion of the orchard. The spraying was done April 21 and 22.

One lot was sprayed with the wash as follows:

Lime	1 pound.
Sulphur	1 pound.
Salt	1 pound.
Water	4 gallons.

Lot two was sprayed with the following:

Lime	1 pound.
Sulphur	1 pound.
Water	4 gallons.

Lot three was sprayed with:

Lime	½ pound
Sulphur	1 pound.
Water	4 gallons.

In the fourth lot lime only was used as follows:

Lime	1 pound.
Water	8 gallons.

Two subsequent visits were made to the orchard, one before the hatching of the eggs and one after, but I could not find the least evidence of any good having been accomplished by any of the four treatments.

APPLE LEAF-APHIS.

Aphis pomi DeG.

A few years ago practically all the accounts of plant lice on the foliage of apple trees were written of one species, which was known under the scientific name, *Aphis mali* Linn. Dr. John B. Smith, of Rutgers College, New Jersey, and others, had noticed that accounts of the insects in other localities did not agree with their own observations, but not until Prof. E. Dwight Sanderson* published the results of his investigations, was it made clear that, instead of having one apple aphis in the United States we have several.

We have at least two species in Montana, but one of these, the Apple Leaf-aphis, is far more common than the other and is responsible for practically all the injuries.

CHARACTER AND EXTENT OF INJURY.

No fruit pest has been more frequently inquired about in the letters to this Station than has this aphis. These letters, as well as the writer's experience in various parts of the state, show conclusively that the species are very troublesome and at times a very injurious pest. It is universally felt that as a rule young trees are much more susceptible to attack than trees in bearing. The writer's field notes record one notable exception to this in the case of a large orchard in Flathead county, composed of trees which had been in bearing for many years, which were so badly infested as to have the foliage withered, and the fruit undersized and poor.

A prominent characteristic of the work of the aphis is the curling of the leaves. In this respect there is a marked difference between the effect on the tree of the work of this species and of "Fitche's apple aphis," which, on the whole, is more common in the United States. In curling, the deformed leave usually takes a characteristic shape. The surface becomes irregularly raised and the whole leaf curls bringing the under surface inside and the upper surface exposed. The tip of the leaf rests upon its base, not in the middle, but to one side

*Thirteenth Annual Report of the Deleware College Agricultural Experiment Station.

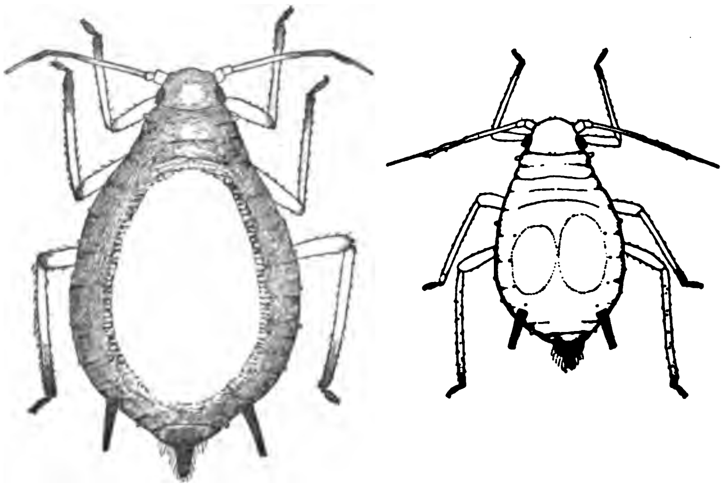


Figure 4. Wingless viviparous female on left: oviparous female on right—greatly enlarged. (Sanderson, 18 Ann. Rept. N. J. Exp. Station).

or the other of the mid-rib. The lice live inside of the curled leaf, a fact which has much to do with the difficulty in controlling them with insecticidal spıays.

There is some reason to believe that the presence of the lice in large numbers on a tree has the effect of keeping the sap in the tree late in the fall, thereby making it more liable to injury by cold weather. It 's certain that badly infested leaves on the ends of the new growth often fail to mature and remain on the tree throughout the winter. This is often noticeable on trees in the nursery row.

The general injurious effect of the lice is to check the normal growth of the tree. This office has many records of this effect in a serious degree.

We have never found this louse occurring in great numbers on the young buds in the spring as is often the case with "Fitche's apple aphis." As a rule, only a few scattering lice are to be found early in the season, and our exeprience has shown that frequently only here and there a tree will be found infested in the spring of the year, though as the season progresses the lice will gradually spread throughout the orchard.

DESCRIPTION AND LIFE HISTORY.

Like many other plant lice, the apple-aphis passes the winter in the egg state. In the spring the eggs hatch, producing very minute, dark greenish lice which may be found crawling about over the surface of the bark or closely nestled on the young buds and expanding leaves.

The spring of 1902 was looked upon as being very cold and backward in the Gallatin valley, and the writer was much surprised in going into the Station orchard on April 16th to find an abundance of newly hatched lice. The buds had not started and were no more swollen than they were the fall before. There had been a few days of hot weather which had caused the lice to hatch, but had not been of long enough duration to start the buds. Part of the lice had been feeding and had distinctly increased in size.

On April 19 a cold storm came and on the 20th there were about three inches of snow. For the next few days the writer was out of town, but on May 1 the trees were examined and the lice were found to have been nearly all killed. Only two living ones could be found and many dead bodies were still attached to the twigs. Since that

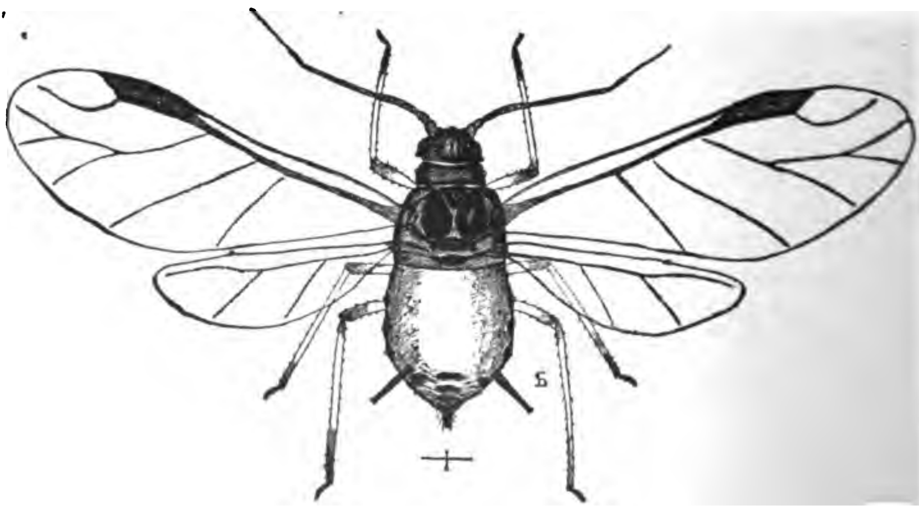


Figure 5. Winged viviparous female greatly enlarged. (Sanderson, 13th Ann. Rept. N. J. Exp, Station.

time, we have observed a similar, though less extensive, early hatching and killing of the lice.

If not destroyed by natural enemies or climatic conditions, the young lice in due time become mature and begin to produce young. Dr. Smith of New Jersey* found that about fifteen days were required for the first generation to reach maturity after hatching. The lice are known as the "Stem mothers," (See Fig. 4, b). They are wingless and are greenish in color. No males are produced from the eggs and the stem mothers are able to produce young without them.

The young of the second generation (offspring of the stem mothers) are produced alive—not hatched from eggs—and are able to begin feeding almost immediately. They settle down near the mother and one may often find a stem mother with her large family close by her. Our office notes show that the stem mother gives birth to young at the rate of from one to fourteen per day, and that she continues day after day for fully eighteen days, producing an average

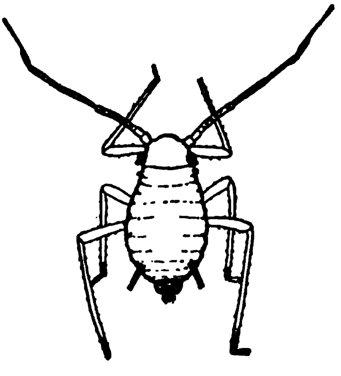


Figure 6, Male of the oviparous generation greatly enlarged. (Sanderson 14th Ann. Rept. N. J. Exp. Station.

number of about six or seven. Thus each stem mother produces fully 100 young.

*Bulletin 143 of the N. J. Experiment Station.

Dr. Smith found that the second generation matures in nine or ten days and that of this series about three-fourths are winged; that the third series matures in about two weeks, less than one-half being winged and that thereafter no more winged forms appear but that seven series of parthenogenetic females in all appear before the end of the season. The 8th and last series is made up of males and females. Late in October, after the mating of the sexes, the females deposit the eggs which remain on the trees during the winter. Figure 4, right hand figure, shows an oviparous female. Figure 6, a male of the oviparous generation.

A part or all of the winged individuals of the early generations fly to other trees. A winged parthenogenetic female is shown at Fig. 5.

The eggs are minute, glossy black objects, oval in shape. They may be found on any part of the tree from the base of the trunk to the tips of the twigs, and are usually more abundant in the crevices of the bark and around the buds than on the exposed, smooth surfaces.

A very large proportion of the eggs, probably upward of 90 per cent, failed to hatch during the three years that we had the species under special study.

NATURAL ENEMIES.

Of the various natural enemies that feed upon the plant louse, none is of greater value than the Fire-marked Lady-bug (*Hyperaspis 5-signata*). Next in importance are certain species of syrphus flies. Besides these we have observed a Braconid parasite, a small fly that has not yet been named and the "Aphis Lion."

After two years of close observation of the babits of this lady-bug we are prepared to say that it is a very prominent factor in the prevention of the aphis from becoming exceedingly abundant and destructive. During the latter part of May and in June the beetles were found in great numbers in the Experiment Station orchard, and in various other orchards, running rapidly over the limbs and twigs in search for the young aphids. The number they eat when in confinements is astonishing.

In a previous paragraph we have called attention to the fact that only a comparatively small number of stem mothers are to be found

early in the season and that the large numbers to be found later in the season is the result of the rapid multiplication. It is apparent,

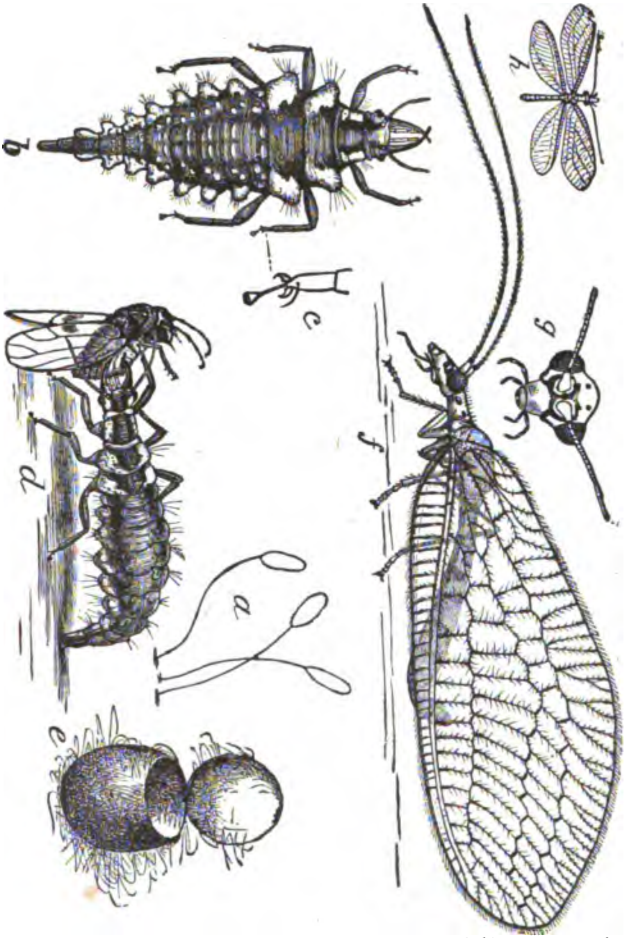


Figure 7. The Lace-winged fly, or Aphis Lion. a, egg: b, full grown larva: c, foot of same; d, same devouring a Psylla; e, cocoon; f, adult insect; g, head of same; h, adult. natural size—all enlarged except h. (Marlatt Circular 7 Sec. Series. Div. of Entomology, U. S. Dept. of Agr.)

therefore, that the comparatively small number of lice that the beetles eat early in the season must have a great effect in the abundance of the lice later in the season.

Though the larvae of this lady-bug eat large numbers of the lice later in the season when they have become very abundant, we look upon the work that they do as being of much less value than that of the adults.

The Surphus fly larvae are probably of greater usefulness than the larvae of the lady-bug since they are usually more abundant, but like the beetle larvae, they do not appear on the scene until the lice have become abundant and are multiplying with such rapidity that it would require a large number of destroyers to dispose of the increase alone. Figure 8 illustrates a common species of lady-bug of the East, while at Figure 2, plate 1, is shown an adult of the species here discussed. Figures 3 and 4 of the same plate show the eggs of the same species and at Figure 5 is shown a full grown larva.

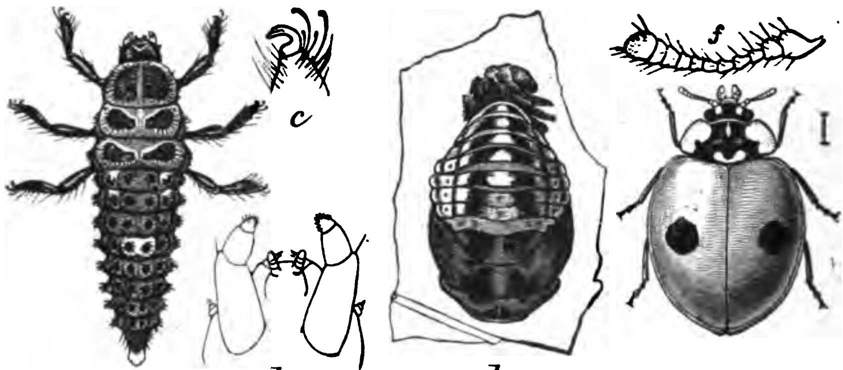


Figure 8, The Two Spotted Lady Bug; a. larva; b, mouth parts of same; c, claw of same; d, pupa; e, adult; f, antenna—all enlarged. (Marlott Circular 7, Sec. Series, Division of Entomology U, S. Dept. Agr.)

REMEDIES FOR APPLE LEAF-APHIS.

In spraying for this aphis we would emphasize the importance of watching for the individual infested trees here and there in the orchard and treating them before the lice spread to the other trees. In other words, the spraying for the apple leaf-aphis should be done and out of the way early in the season, for under ordinary circumstances, when vigorously fought early in the summer, though some lice escape, there will be so few left that the natural enemies will be able to keep them from overrunning the orchard.

The value of prompt treatment is apparent when we realize the enormous power of multiplication with which nature has endowed these insects. In a previous para-

graph we have shown that the stem mother's maximum power of production is upward of 100 young, and it is probable that later generations can give birth to a similar number.

Acting on the basis that all of the young of each generation come to maturity and produce the full unmber of young, we find that the progeny of one stem mother during one summer is something enormous.

1st generation	1 aphis.
2nd generation	100 aphids.
3rd generation	10,000 aphids.
4th generation	1,000,000 aphids.
5th generation	100,000,000 aphids.
6th generation	10,000,000,000 aphids.
7th generation	1,000,000,000,000 aphids.

Thus starting with one aphis in the spring we would have in the seventh generation one trillion aphids, a number which the human mind cannot appreciate. Under natural conditions, however, the insects are decreased in number from one cause and another, all thro' the season, so that, while they increase very rapidly, they never do so to the extent above indicated. At the same time, however, it is easily seen that the destruction of a large proportion of the first and second generations will very markedly affect the numbers throughout the season. There seems to be little doubt that the killing of the first generation, by inclement weather in some seasons and the absence of storms in other seasons account for the great variation in abundance and destructiveness of this louse in different seasons.

Because of the great difficulty in controlling the insect after the leaves of the trees have become curled, the writer has undertaken to learn if it is feasible to destroy it in other ways. An extensive series of experiments in fumigation with the deadly hydrocyanic acid gas was conducted. In these experiments we used a large canvas tent, a large paper box and a small air-tight wooden box constructed for such work. We will not at this time give the detailed results of these experiments but will indicate the lessons they taught. Detailed instructions for the use of this substance will be found on another page of this report. (See index.)

We found that every aphis could be killed without the least injury to the foliage. Even though the experiments were conducted in both cloudy and bright, hot weather, not a leaf was injured in the whole series of tests.

We used the cyanide in strengths varying from 0.10 grams per cubic foot of inclosed space up to 0.30 grams and while 0.10 gram killed practically all the lice, and, on the other hand, 0.30 did not injure we decided upon 0.20 gram per cubic foot as being the suitable amount to use in practical work.

The time of exposure was 20 minutes.

Considering the fact that by a timely and persistent use of sprays and washes the aphis may be brought under control, I very much doubt if this treatment should be considered as a suitable remedy except in the case of very large owners or in company orchards where the expense of providing a complete fumigation outfit would be justified. Having the equipment already at hand it would cost about 4½ cents per tree to treat a large orchard.

Information rgarding fumigation boxes suitable for such work as this may be obtained from Professor Johnson's work on fumigation published by the Orange Judd Publishing Co., New York.

We also undertook a series of experiments with the use of the lime-sulphur and salt wash as means of destroying the egg during the winter. We sprayed a series of trees with this wash and modifications of it in the Experiment Station orchard and at Lo Lo. Subsequent examinations of the trees at Bozeman showed that while none of the eggs hatched on the trees that were sprayed they also failed to hatch on all the other trees in the same part of the orchard that had not been sprayed. We therefore felt that the experiment had taught us nothing. The Lo Lo experiment also failed to be of value for the same reason.

During the past few days a bulletin from the Idaho Experiment Station, written by Proffessor Aldrich (Buletin No. 40) entitled "Winter Spraying for Aphis Eggs" has come to my desk. The bulletin gives in detail Prof. Aldrich's experience in the use of seven different sprays used in the winter treatment of eggs of this aphis. The seven sprays are the following:

1. Pure kerosene.

2. Kerosene emulsion, one-third kerosene.
3. Kerosene emulsion, one-fifth kerosene.
4. Sulphur and lime wash, 1-1-2. (One pound sulphur, one pound lime, two gallons water.)
5. Sulphur and lime, 1-1-4.
6. Sulphur and lime, 1-1-8.
7. Crude petroleum emulsion, 10 per cent. strength.

From the results of his experiments Prof. Aldrich drew the following conclusions:

"Crude petroleum could not be uniformly applied. The emulsion was very unstable, and the oil is much too thick to apply pure. No damage resulted to the trees, but in many cases the eggs of lice were not destroyed.

Pure kerosene seriously injured the trees to which it was applied, but killed all the eggs.

Kerosene emulsion of one-third strength injured the foliage to some extent, though not very seriously; it did not kill the eggs with any uniformity. In one-fifth strength it did not injure the foliage, but was not at all effective in killing the eggs.

Sulphur and lime did not injure the foliage in the least, however strong. In the 1-1-2 and 1-1-4 proportions it killed almost all the eggs; it is a question whether the very few that hatched had not been missed by the spray.

Of the seven kinds of spray used, the choice for commercial purposes would undoubtedly be No. 5, sulphur and lime in the 1-1-4 proportion, or what is called the "Piper formula."
1-1-4 proportion is probably a successful winter treatment, it will be applicable only on small trees that can be closely examined and thoroughly sprayed.

In conclusion, we recommend that Montana apple growers make careful, conclusive tests of the 1-1-4 lime-sulphur wash as a winter treatment, and mean while place their main dependence on the use of kerosene emulsion and whale-oil soap or quassia-whale oil soap solution, spraying trees that are generally infested and dipping the

He further concluded that while the lime-sulphur wash in the extremeties of limbs that are infested only at the ends of the branches.

Formulae for these washes are given on a later page. (See index.)

THE FLAT-HEADED APPLE-TREE BORER.

Chrysobothris femorata Fab.

One of the most troublesome insect pests with which the Montana fruit-grower has to contend, is an apple-tree borer, which in the larval stage is expanded and flattened near the anterior end, as shown in figure 9, a, an appearance which has led to its being called "the flat-headed borer." Besides attacking the apple, the borer has been recorded also on various other deciduous trees, among which are pear, peach, oak, maple, mountain ash, box-elder, hickory, chestnut, sycamore, horse chestnut, redbud and currant. Mr. F. H. Chittenden of the U. S. Dept. of Agriculture, from whose circular, (Circ. 32, Division of Entomology) many of the facts in this paper are taken, states that cherry, beach and white birch are probably food plants, while an unknown authority has stated that elm, tulip, and cottonwood are also host-plants.

Although not considered to be a pest of first class importance this species has been doing a great deal of damage in this state, particularly in the Bitter Root valley, and there is an increasing demand for information concerning its habits and the means of controlling it. It has been particularly destructive on young orchard trees, girdling the trunk near the ground and killing the trees. The accompanying photograph (see Plate III, Figure 7) shows the manner in which many trees have been affected and killed in Montana. The only explanation the writer has to offer as to the cause for the rather unusual numbers of this insect, is that under the climatic conditions in Montana trees seem to be affected to a considerable extent with sunscald, an affection which leaves the trees in an inviting and favorable condition for this insect. It has long been known that this insect prefers for a breeding place trees that have been previously weakened by some other cause. Observation has shown that trees which have been injured on the side exposed to the winter's sun are often selected by the adult in depositing their eggs.

Young trees are affected principally on the main stem close to the ground, but on old trees the borers work on any part of the tree except the smaller limbs and branches.

Like other members of the same family of beetles (Buprestidae) the adults are diurnal in habits and are most active during the heat of the day. By a close search in an infested orchard during the season of the year when the adults are out, one may find them basking in the sun on the trunks of the trees and on prostrate logs.

DISTRIBUTION AND OCCURRENCE IN MONTANA

The flat-headed apple-tree borer is a native of North America insect. In spite of this fact, however, we believe that it is an introduced species in Montana. None of its principal food plants, so far as known, are native to the state, or if present, occur only sparingly, and moreover, its presence has been detected only in restricted localities. We think it much more probable that the insect was brought into the state on some of the earliest shipments of trees from the older apple growing regions.

It is a widely distributed pest throughout the United States east of the Rocky Mountains, and in southern Canada.

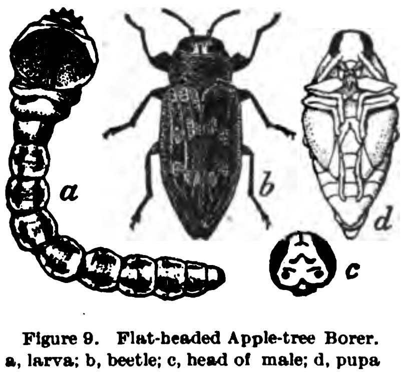


Figure 9. Flat-headed Apple-tree Borer. a, larva; b, beetle; c, head of male; d, pupa —twice natural size. (Chittenden, Circular 32, Sec, Series, Div, of Entomology U. S. Dept. of Agr.)

LIFE HISTORY.

The eggs, which are pale brown and about one-eighth of an inch long, are laid on the trees during the hot summer months. One observer, Dr. Riley, found them being laid from June to September, but our observations in Montana indicate that while a few beetles may be found on the trees later in the season the majority are out and

depositing their eggs late in June, and early in July. In about three weeks, the eggs hatch and the young larvae bore under the bark, where they feed for three years, first just under the bark and later in the woody parts of the stem. On young trees they most commonly occur at about the surface of the ground as shown in the photograph above referred to. The location of the burrow may often be detected from the outside by the discoloration or slightly sunken condition of the bark.

At the end of three years from the time the egg was deposited the beetle bores out from the pupal chamber which it constructed at the end of its larval life. The sexes mate and the eggs are deposited for the new generation.

NATURAL ENEMIES.

The downy wood-pecker which is so common in Montana and which is so often seen in our orchards, is the fruit-grower's friend. Besides picking up miscellaneous pests it locates burrows of this borer and extracts them in considerable numbers. In the older orchards of Montana scarcely a tree can be found that does not bear the marks of wood-peckers, a large proportion of which are made by this species.

METHODS OF CONTROL.

Borers as a class of pests are difficult to control. When once in a tree they cannot be reached with an insecticide. They may in many cases be removed by means of a sharp knife and a wire but their presence is not usually detected until a large part of the damage has been accomplished, and the injury done to the tree in removing the larvae may be greater than would be done if they were left to do their worst. It has been found, therefore, that clean, strong, cultural methods and the use of deterrent application on the trees, both of which are preventatives, constitute the best means of control.

In the first place, in planting out a young orchard the trees should not be allowed to become weakened and so rendered liable to attack. Young trees in an exposed position should be protected against the strong rays of the winter's sun. The alternate thawing and freezing on the exposed side of the trunk produces the condition

known to all as sun-scald, and makes typical conditions for the borers. Dead or worthless trees should not be allowed to stand and become a menace to the healthy ones. It is a bad practice to have a brush pile made up of dead trees and prunings at the side of the field. Such piles should be burnt very frequently, for they soon become nurseries of pests.

In a locality known to be infested with this borer it is often desirable to use deterrent applications on the trunks and larger limbs of both weakened and healthy trees. For this purpose, a number of substances have been recommended. Some use old newspapers as mechanical barriers placed about the base of the tree.

Mr. Chittenden recommends that these papers be put on the trunk for about two feet from the ground up, and that above the paper a carbolated or akaline wash be applied. Wire netting is sometimes used.

The paper and netting not only prevent the deposition of eggs but also prevent the escape of the beetles that emerge underneath them.

Among the substances that may be used as washes to make the surface of the trees objectionable to the adult beetles and so prevent them from depositing their eggs are the following:

1. A thick solution of whale-oil soap.

2. Soft soap rendered thick by the addition of caustic soda or potash in solution.

3. Either of the above washes would probably be made more effective by the addition of crude carbolic acid at the rate of one pint to ten gallons of the wash.

James Good, 939 and 941 North Front Sstreet, Philadelphia, Pa., offers for sale a product known as Caustic Potash Whale-oil Soap, which of itself would be a good substance for this purpose. It should be diluted with sufficient water to make a thick fluent mass, and applied to the trunk and limbs of the trees to be protected. Such washes when not of a quality that makes them injurious to the hands, are sometimes applied by a man wearing old mittens or socks that are saturated with the wash.

THE PEAR-LEAF BLISTER MITE.

(*Phytoptus pyri* Scheuten.)

Though probably of European origin the pear-leaf blister-mite is now widely disseminated throughout the world, having been distributed by the agency of traffic in nursery stock. It is sparingly distributed in Montana, but where well established is a troublesome pest.

NATURE OF INJURY.

As the leaf-buds of affected trees unfold in the spring there may be seen red blister-like spots and blotches which in severe cases may involve practically all the surface of the leaf. At first the galls are more distinctly seen on the upper surface of the leaves but later in the season the spots turn brown, owing to the death of the tissues comprising the blisters, when the affected spots become more apparent on the under side of the leaves. The blotches often take the shape of elongated patches one on each side of the midrib.

In each blister, on the under side of the leaf, may be seen one or more minute holes that lead to the cavity of the blister and usually visible only under a lense or microscope.

Within these blisters composed of abnormal plant tissues, the mites live, feeding on the juices of the plant. Under the shelter of these galls they are very well protected, not only from wind and rain which might easily sweep them off, but also against insecticidal treatment. The tissues on the inside of the galls also furnish better facility for the mites to acquire nourishment than would the thicker layers of cells on the surface. The freshly formed galls are thick and succulent, but as they die and turn brown they shrivel and dry. Badly affected trees lose their foliage long before the normal time which must be an injury to the health of the tree.

THE MITE.

The mites that produce these galls are very minute, being scarcely visible to the naked eye. Under a high power microscope, the body is seen to be elongated in form, about four times as long as wide, and has the appearance on the surface of being made up of

a large number of fine rings. There are four legs, all of which are placed at the anterior end of the body and though small they enable the mite to move rapidly. The head is made up chiefly of a conical snout within which are two lance-like jaws. To cover a linear inch about 150 mites placed end to end would be required.

LIFE HISTORY.

From the eggs which are laid in the galls by the parent mites the young hatch, and, crawling out of the hole, go in search of an uninjured spot in the leaf. Then, boring through the surface they start new galls. The mites remain in the galls until the end of the season when they crawl to the buds and seek shelter for the winter under the scales.

Some mites remain on the leaves too long and are borne to the ground when the leaves fall.

MEANS OF DISTRIBUTION.

Of itself the mite cannot travel far. For distant dissemination it is dependent upon outside agencies and has doubtless been spread from country to country on nursery stock. From tree to tree in the same vicinity they may be carried on the feet of the birds, or blown by the wind on the leaves in the fall of the year.

REMEDIES.

The only vulnerable point in the life cycle of this mite is when it is secreted under the bud scales after the leaves have fallen. Prof. M. V. Slingerland found that the mite "can be nearly exterminated in a badly infested orchard by a single thorough spraying of the trees in winter with kerosene emulsion diluted with five to seven parts of water." In all cases of treatment with a spray or winter wash, we recommend that no twigs or branches that have been pruned off be left on the ground.

We recommend that the leaves from infested trees be gathered and burned and not allowed to blow about.

Having learned from various fruit-growers of the state that they had not found the kerosene emulsion treatment to be satisfactory,

the writer undertook a series of tests of the lime-sulphur-salt wash as a remedy. The experiments were conducted in the orchard of Mr. C. M. Allen of Lo Lo. I would here express my gratitude to this gentleman for many courtesies extended to me, both in connection with these experiments and at other times.

In the experiments Mr. Allen's entire orchard of 190 trees was used and we feel entire confidence in the results we obtained. The spraying was done on April 21 and 22, the pear buds being swollen almost to the point of opening.

In the various tests we used the following:

Spray No. 1.

Lime	1 pound.
Sulphur	1 pound.
Salt	1 pound.
Water	4 gallons.

Spray No. 2.

Lime	1 pound.
Sulphur	1 pound.
Water	4 gallons.

Spray No. 3.

Lime	½ pound.
Sulphur	1 pound.
Water	4 gallons.

Spray No. 4.

Lime	1 pound.
Water	8 gallons.

Ten trees were used in experiment No. 4 (lime and water only) and ten trees were left unsprayed. The remaining trees were about evenly divided in experiments Nos. 1, 2, and 3.

The results of the tests were very satisfactory and seemed conclusive. The mites were practically exterminated on all trees treated with sprays 1, 2, and 3. The mites on the ten trees sprayed with No. 4 were, so far as we could determine, wholly uninjured. These trees and the ten left unsprayed were badly affected with the mites after the foliage expanded.

Directly the other side of a barbed wire fence are more pear trees badly affected with the mite. The two pear orchards are really

but one, since Mr. Allen's orchard was purchased and fenced off from the other larger one, the fence, in fact, passing diagonally through one row. The trees on the other side of the fence were badly infested the following summer, thus giving us greater confidence in the efficiency of our treatment.

It appears that all of the first three sprays were equally effective Spray No. 3 ½-1-4 contains only enough lime to cause the sulphur to go into solution, thereby making the caustic ingredient of the mixture. The spray when ready to apply is clear and transparent instead of milky as is No. 2, which has an excess of lime. In spray No. 1, the excess of lime goes onto the tree merely as a whitewash. We are not prepared to say that there is not some benefit in having this excess of lime, and for the present we recommend the use of spray No. 2. We do not feel that the addition of salt in spray No. 1 renders the wash of any more value.

In conclusion, we recommend, as a means of holding this mite in control, a thorough spraying with lime-sulphur-salt wash in the 1-1-4 proportion, in the spring of the year before the buds open. Directions for the preparation of this wash will be found on another page of this report. (See index.)

GRASSHOPPERS.

During the past three years a considerable amount of damage was done by grasshoppers in eastern Montana. An extensive territory was more or less affected, in some localities the grasshoppers being so abundant that there was no vegetation left. From this extreme there was every gradation down to no injury. During these three years the grasshoppers steadily increased and the seriously affected territory was extended.

The injuries have been principally confined to the fenced and open ranges used by the stockmen in grazing cattle, sheep and horses, but some damage was done to grains, cultivated grasses and alfalfa. We received reports also of damage to fruit trees and to garden crops.

Coincidental with the appearance of the grasshoppers has been a series of years in which the rain and snowfall has been much below the average. Aside from any direct or indirect influence which this scarcity of moisture may have had on the unusual increase of grasshoppers, it certainly very much shortened the crop of grass. While the amount of grass that the grasshoppers ate would have been missed even if there had been a full growth, it is certain that what they took was more seriously missed on account of the scarcity of grass.

Roughly speaking, the territory injured through the combined effects of dry weather and grasshoppers may be said to be embraced in that part of Montana drained by the Yellowstone river east of the town of Big Timber. Not only were the valleys of the tributaries of the Yellowstone affected but the cross country as well. We also received reports of injury in other scattering localities. One report came through Townsend from the country northeast of that town and we were notified of injury on the range in the eastern part of Madison county.

One species, the yellow-winged locust, was very abundant in restricted localities in and about the Gallatin valley. We also noted the big-headed grasshopper to be more abundant than in previous years and in two instances the yellow-striped locust was found in great numbers in the edges of this valley.

INJURY NOT CAUSED BY THE ROCKY MOUNTAIN LOCUST.

Many persons have supposed the "old-fashioned" or Rocky Mountain Migratory Locust to be responsible for the losses in Montana. Our investigations of the subject, however, show that no one species is alone the cause of the loss and the above species (*Melanoplus spretus* Uhler) if present in the state at all is very rare. During the five summers that I have been collecting in all parts of Montana I have not captured a single example of this interesting species. Moreover, I learn by letter from Prof. Gillette of Colorado that he has had a similar experience, having been unable to find any specimens during a longer period in his state.

In our various trips into the worst affected regions we found a fairly uniform state of affairs throughout. On the range two or three species, taken together, constitute a large proportion of the total number, though in restricted localities one or another species besides these was more abundant. The three most common species on the range were the Big-headed locust, (*Aulocara elliotti*), the Lesser Migratory locust (*Melanoplus atlanis*) and the Yellow-winged locust (*Camnula pellucida*). In point of abundance the Big-headed grasshopper was the leading species of the three. The Lesser Migratory Locust was second in importance. It prefers the dryer uplands to the irrigated valleys, but in many cases it was found in great abundance in grain fields, particularly on the benches and in non-irrigated fields.

The Yellow-winged Locust is more local in its distribution, often occurring in immense numbers in restricted localities and at times becoming very injurious to grasses and grains.

We found the two-striped locusts to be common in practically all the cultivated fields that were injured by grasshoppers. This species was particularly injurious to alfalfa, the succulent stems and leaves of this plant apparently suiting its taste.

LIFE HISTORY.

All our particularly injurious species are alike in the main features of their life history. The winter is passed in the egg stage in

the ground. The eggs are about one-fifth of an inch in length and are deposited in compact masses or "pods" which are arranged vertically, or slightly inclined, just below the surface of the ground.

In making the hole in the ground to receive the eggs, the female makes use of special organs at the extremety of the abdomen. Placing the point of the abdomen against the ground the pointed organs work rapidly back and forth and as the hole is made the abdomen settles into the earth. When the hole is completed it is filled with the mass of eggs and a viscid frothy substance.

Prof. C. V. Riley's classic illustration of the process of egg-laying of the Rocky Mountain Locust, together with his description of the process, show that in that species the eggs are laid in four regularly parallel rows and that the number of eggs varies between 20 and 35. He also found that two or three such egg-masses were deposited by each female insect.

The two-striped locust lays a larger number of eggs than this for we have counted as high as 62, in a mass, and two or three masses are deposited. The Big-headed Locust (*Aulocara elliotti*) probably deposits only two masses.

In general the places most chosen by the females for the purposes of egg-laying are those at which the soil is fairly free from grass-roots, or other roots that would interfere with boring the holes. Such places are found on the sides of roads, in abandoned roads, among tall weeds, etc. When the mating season comes the adults of a species gather into colonies where they stay for the remainder of their life. As a result, the young are often found in the spring of the year in more or less restricted localities.

In our investigations of the outbreak of grasshoppers in Montana in 1903 we found that the Big-headed grasshopper paid little attention to where the eggs were laid; for miles and miles over the denuded ranges the females could be found performing this act.

In the spring of the year, in some species earlier than in others, the eggs hatch into very small nymphs which on close examination are seen to resemble adult grasshoppers, but there are no indications of wings. As they increase in size and molt from time to time, rudimentary wings appear which increase in prominence with each molt until the last when with fully developed wings the insect is mature

and ready to lay eggs. While a few species of grasshoppers pass the winter as adults and a much larger number as nymphs, thereby making it possible to find some grasshoppers in the early part of the summer, it is a matter of common knowledge that they are much more commonly seen in August and September. This is not because there are more grasshoppers in the latter part of the season but because when winged they are much more conspicuous than in the younger stages.

MONTANA'S MOST COMMON AND DESTRUCTIVE SPECIES.

In the following paragraphs we present a few of the leading facts regarding the most common species of grasshoppers that we have taken in middle and eastern Montana. They are not arranged in the order of their importance except the first five or six. Not all the species discussed are of great economic importance but all are common and liable to be observed by anyone. Since some of the species are not yet known by vernacular names, we have used the scientific name of all, but have given also the popular name when one is known.

I am indebted to Prof. Lawrence Bruner of the University of Nebraska for valuable information concerning our species and for the determination of a large number of species including a part of those discussed in this paper. Dr. L. O. Howard of the Division of Entomology at Washington has also very kindly identified a number of species for me.

Aulocara elliotti Thomas. THE BIG-HEADED GRASSHOPPER.

This grasshopper, in point of numbers, stands first in the series here discussed. While it has been mentioned as being injurious in various parts of the United States, it has never before been considered a prime cause of devastation. It occurs throughout western United States and is a true grass-eating species. When viewed from above or from the side the head is large (see figure) and the tibiae

are bright blue; the antennae of the male are long. It occurs principally on the range, in Montana, having seldom been found in irrigated valleys.

Melanoplus atlanis Riley. THE LESSER MIGRATORY LOCUST

This species is distributed throughout most of the United States and Canada and often becomes so abundant as to be injurious. In Montana we have found it in cultivated fields where it has occasioned considerable loss, and on the range where in association with *A. elliotti* it has been injurious. The tibae are usually red. The size and general appearance of the species are shown on the accompanying plate (Plate IV, figures 1 and 2).

Camnula pellucida Scud. THE YELLOW-WINGED LOCUST.

It may be safely said that not a year passes in which this species does not become injurious in either one part or another of the United States, usually in the northwest. It feeds particularly on grasses and grain. In Montana it has been found to be local in its distribution and has been destructive on the range in only a few restricted areas. The under wings are yellow, the upper wings and general surface of the body are variable in color, between yellow and brown.

Melanoplus bivittatus Say. THE TWO-STRIPED LOCUST.

This is among the larger grasshoppers of Montana. It occurs throughout the greater part of the United States. It is especially injurious in cultivated fields and so far as our experience goes is practically the only species that has caused injury to alfalfa. The femora have longitudinal stripes and there are two yellowish stripes on the back.

Hippiscus neglectus Thomas.

We found this grasshopper to be fairly common over the larger part of the affected territory. Its appearance is well shown in the accompanying figure. (Plate VI, figure 2.)

Spharagemon æquale Say.

This grasshopper is often met with in the heat of the day, is a strong flyer and a difficult one to catch. In some places it was so common as to be somewhat injurious.

Arphia tenebrosa Scudder.

This grasshopper fies with a clattering sound, often poises itself in the air in the heat of the day, remaining in one spot with the wings rapidly vibrating.

Chortophaga viridifasciata DeG. THE GOAT-HEADED GRASSHOPPER.

This exceedingly variable species, found in the early part of the season, often assembles in colonies. It varies between bright green and dull brown.

Dissosteira carolina Linn. THE CAROLINA LOCUST.

This grasshopper is the species known to most people as the one that poises in the air making a peculiar rattling or rustling sound, settling to the earth as the sound dies out. It occurs commonly along dusty roads and hot,gravelly places as along railroad tracks. The writer has often observed it to be abundant in various parts of Montana.

Cordillacris occipitalis Thomas.

This species occurs on the plains east of the Rocky Mountains. We have found it very abundant in eastern Montana.

Melanoplus dawsoni Scudder.

This species when mature has rudimentary wings which reach only about half-way to the end of the abdomen. The under side is yellow, with prominent black bands on the abdomen. It has been common in lowlands in the Gallatin valley and in the Yellowstone valley.

Encoptolophus sordidus Burn. THE CLOUDED GRASSHOPPER

Often met with in the field and somewhat resembles C. pellucida.

Acrolophitus hirtipes Say.

This grasshopper of striking appearance, is uniformly green throughout. It occurs in restricted localities, often in considerable abundance, where in contrast to other sombre-colored grasshoppers, it is quite conspicuous.

INSECT ENEMIES OF GRASSHOPPERS.

Grasshoppers have a large number of parasitic enemies and when the grasshoppers as hosts become abundant, their parasites, because of a plentiful supply of food, become numerous also and soon gain the mastery over the hosts. This balancing process is continually active. While we cannot say positively what is the cause of the appearance in Montana of grasshoppers in unusual numbers it is probable that parasites as a direct or indirect cause have had a great influence.

Various correspondents have called our attention to the presence of minute red spots on the bodies of grasshoppers. These red spots are the bodies of a red mite which occurs commonly throughout the state, and which doubtless does some good in preventing the undue increase of grasshoppers. They have often been mistaken for eggs of parasites but there is no reason for confusing the two, since the eggs of parasitic flies are white.

In every part of the grasshopper affected sections of the state that we visited in the summer of 1903 we found dead bodies of grasshoppers which contained maggots or larvae of a fly. Some of these were reared in the laboratory to the adult stage and the flies were sent to Dr. L. O. Howard for determination. He reported the fly to be *Sarcophaga cimbicis* Townsend. We are unable to state whether this fly killed the grasshopper or whether the larvae were merely feeding as scavengers on the dead bodies of grasshoppers that had died from other causes.

It was noticeable that a blister beetle or Spanish fly whose scientific name has not yet been determined was very abundant throughout the Yelowstone valley from Columbus eastward. We

received a few letters notifying us that these beetles had been injurious to garden plants and other plants of value. This species and various other of the same family (*Melodidae*) are well known to be very beneficial in the larval stage as destroyers of the eggs of locusts. In brief their life history is the following: In the latter part of the summer they deposit their yellowish colored eggs in the ground, each female producing four or five hundred eggs. The eggs hatch in about ten days into long-legged larvae. These larvae are very active and they run about over the ground searching for eggs of locusts, finding an egg pod they enter it and begin devouring the eggs. It is said that if two larvae come upon the same egg-pod a deadly combat occurs, resulting in the death of one or the other, leaving the successful contestant sole owner of the store of food. As the larva feeds and grows it molts from time to time producing remarkable changes, until in place of the long-legged larva there is one with short legs and rudiamentary mouth parts. The mature beetle appears again the next spring.

Besides the enemies we have mentioned, which are among the most important, are many others which, taken together, doubtless do much to reduce the number of grasshoppers.

REMEDIES.

The remedies that have been devised in the various parts of the country are not adapted to the conditions we find on the grasshopper-ridden ranges of Montana. They apply much better to the agricultural fields of the middle-west states, but some of them may be used effectively in the agricultural valleys of this state. We give below a few remarks regarding the most important remedies that are known, leaving the farmer to select for himself the one most suitable for his conditions.

Ploughing.—Late fall or early spring ploughing is the best of all artificial remedies. It is practiced for the purpose of destroying the eggs and it follows that the eggs must first be located. In our remarks regarding the habits of grasshoppers we have called attention to the fact that in the breeding season the grasshoppers accumulate in more or less restricted areas and that the eggs are laid in

these areas. The observant farmer will locate these patches and by ploughing deeply will place the eggs so far under the soil that when the young hatch they will be unable to reach the surface. Even the young hoppers, when very small, may be turned under in the same manner.

Where ploughing cannot be resorted to, a thorough harrowing, especially with a disc harrow, will result in the destruction of a large number of the eggs by crushing some and exposing others to their numerous enemies and to frosts.

Burning.—When the grasshoppers are young and travel slowly they may be killed on or near the locality where they hatch by covering them with a thin layer of straw and then burning it.

In some sections of the west where crude petroleum can be obtained at small cost it is sometimes employed in the form of a spray as a remedy against young hoppers. This oil kills by contact but additional effectiveness can be secured by setting fire to the oil on the ground.

Bandages.—Some property owners in Montana have suffered injury to their fruit trees by grasshoppers. The young may be prevented from climbing the trees by bandaging the trunks with cotton batting, axel grease or some other adhecive substance. As the grasshoppers acquire wings they may fly into the trees and in such cases relief may be secured by the use of poisonous sprays.

Hopper-dozers.—Hopper-dozers are metallic pans of any convenient dimensions which are partly filled with kerosene oil and drawn about over the field for the purpose of catching the partly grown grasshoppers. Many of the insects after hopping into the

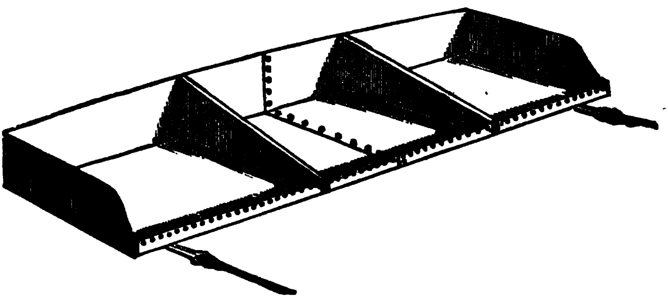


Fig. 10 Hopper-dozer, after Riley.

pans and getting covered with oil jump out again but these are invariably killed. The back of the pan is extended vertically by means of a strip of cloth or canvas supported by upright stakes. See Figure 10. In large fields several hopper-dozers are sometimes attached in series by means of a long pole and drawn by two horses, one at each end of the pole. Two horses attached in this way are much better than one in the middle of the pole because they tend to gather in the grasshoppers rather than drive them away.

The Artificial Use of Diseases.—Under such conditions as occur on the Montana ranges, where the greater part of the injury by grasshoppers has been done, the artificial use of deadly diseases is an attractive subject. If we were able to propagate and distribute a disease which would be communicated from one insect to another and so extended over large areas, the solution of the grasshopper problem would be reached. Various experimenters in the United States have made careful tests of such diseases but thus far very few encouraging results have been secured.

Realizing that the artificial use of diseases, though offering small hope of success, constituted the only hope, the Experiment Station through this department made a careful test of what has been called the South African grasshopper fungus disease. A single tube of this disease from Africa was very kindly given me by Prof. C. P. Gillette of Fort Collins, Colorado. Cultures on potato were made and distributed to about 300 applicants in the state. We also made careful laboratory tests on caged grasshoppers of various species, but so far as we are informed not one grasshopper was killed either in the field or laboratory test. The various other entomologists also failed to get results of decided value. We feel, therefore, that until something entirely new in the form of a disease is known, we will still have to wait for Nature to take her course, except where it is possible, in restricted areas, to use some of the other remedies.

CRIDDEL MIXTURE.

The substance known by this name has lately come into favor as a grasshopper remedy in some parts of the United States. It was first brought to public attention by Dr. James Fletcher, government entomologist of Canada, who, at the meeting of official entomo-

logists at Washington, D. C., 1903, stated that it had entirely replaced the cumbersome and inadequate hopper-dozer. It is made as follows: Take one part of Paris green, two parts of salt and 40 parts of horse manure by measure. Add sufficient water to make the mass soft without being fluid. Distribute through the field to be protected in quantity proportioned by the number of hoppers.

The material may be scattered from a wagon and because of its cheapness may be used sparingly over fairly extensive areas. We recommend that it be given a very thorough test around the edges of grain fields and other crops that may be threatened. We know of no remedy to recommend for use on the the ranges.

THE COMMON TOAD*

It is the purpose of this paper to call attention to the value of the toad to the fruit-grower, the gardener and farmer, to outline its habits and life history and to urge that it be protected against destruction by thoughtless boys.

At first thought an account of the toad may seem out of place in a report of insect life. It is entered, however, on account of my firm belief in its great economic value as a destroyer of terrestrial insects, a large number of which are injurious to the interests of man.

As will be noted, I have freely consulted and often quoted Mr. A. H. Kirkland's paper that treats of this animal, published as a bulletin of the Massachusetts Experiment Station. His paper is the most valuable that has been published on this subject.

FALSE IDEAS CONCERNING THE TOAD.

Since before the beginning of the Christian area students have observed toads and written of their habits. Too frequently, however, actual facts and superstitions have been confounded, with the result that the early literature on this interesting and valuable batrachian is a queer medley of fact and fiction.

For the sake of brevity we will pass over this topic very briefly and omitting an account of the venomous character and medicinal

**Bufo boreas*

virtue, as well as many other equally ludicrous qualities attributed by the ancients of Europe to this harmless and humble animal, will touch upon certain beliefs that are now current in this country.

Perhaps the creation of the imagination that is given more credulity than any other, is, that to touch a toad will cause warts on the hand. Other beliefs that have been held in this country, (we hesitate to say that any of them are now held) are, that to kill a toad will produce bloody milk in cows; that a toad's breath will cause convulsions in children; that a toad in a newly dug well will insure a good and unfailing supply of water; and that a toad in a new made cellar will bring prosperity to the household.

No less absurd than the above are the statements that we often see in the papers to the effect that some particular section has been visited by toads that fell in a recent storm in such numbers as to be very abundant in the roads, on the sidewalks and over the entire surface of the ground. While it may not be an entire impossibility for a toad to be picked up by a tornado or cyclone, no one would accredit such an atmospheric condition with the power of selecting toads from among the other equally movable objects, or if other objects were taken into the upper air along with toads we might rationally predict that both classes of objects would be deposited in the same places.

The explanation of the occurrence of toads in noticeable numbers is usually to be found in the fact that they have either hatched and grown to a sufficient size for migration in some nearby swamp or pond, or that adult toads are on their way to or from such nearby breeding places. It is well known that toads during the sunny hours of the day seek protection under stones, boards, bridges, in dense vegetation or in the soft earth—in other words, moist, cool locations. For a short time after a storm, when the air is cool and the earth and vegetation are wet, the toads are known to venture forth even at midday as they do in the cool twilight hours of the evening and morning.

LIFE HISTORY AND HABITS.

The toad in common with other batrachians, and like reptiles, spends the winter months in hibernation. In the early spring, when

the earth has become warmed, the toad emerges from its winter quarters, and, during the warm hours of the day, makes its way to some pool or stagnant water where it meets others of its kind. A little later, their shrill cry, the mating call, may be heard. The eggs of the toad and those of the frog may both be found in the same pool, the former in long slimy strings, the latter in irregular masses. In about four weeks the eggs hatch and the tadpoles, which at first are very small and very numerous, feed on the vegetable detritus and slime which are found on the bottom of the pond and attached to weeds, sticks, etc.

The tadpole has become full grown and has transformed to a very small toad by about the first of August, in this climate. The young toads leave the pond and scatter in all directions, keeping out of sight because of their sensitiveness to heat except after showers when the earth is cool and damp.

Kirkland states that he removed 1279 ova from one average-sized female which had already commenced laying. This statement indicates great powers of multiplication in this animal. We have observed, however, that a large proportion of the tadpoles never mature into toads.

For hibernating quarters the toad makes use of cavities under rocks, in cellars, in rubbish heaps, etc.

Both in summer and in winter the temperature of the amphibian and reptilian body is about that of the surrounding air or water. When the surrounding medium goes below certain temperatures, the animal becomes torpid, stiff and may even freeze without injury. If brought into a warm room such an animal soon becomes active as in the summer only to return to the same stupor when returned to the cold. That the physiological state of hibernation is not dependent alone on a fall in temperature is shown by the fact that the many animals go into hibernation long before the approach of cold weather and, further, by the fact that other animals hibernate in warm weather during the period that their appropriate food is scarce. Some animals, morever, are not aroused from their hibernating torpor by being brought into a warm atmosphere.

When roughly handled, the toad sercets from the wart-like projections on the back a milky fluid of a most offensive odor. That

this secretion is not objectionable to all animals is shown by the fact that hawks, owls, etc., include toads in their fare.

LENGTH OF LIFE OF THE TOAD.

European literature gives authentic record of a toad that lived 36 years and was then killed by accident. Kirkland, in his paper already referred to, records the results of his inquiry into this interesting matter in the following words:

"Nearly every old New England homestead has one or more semi-domesticated toads whose age can only be conjectured. The writer has sought different parts of the state (Massachusetts) among families who have long resided on the places they now occupy, for some accurate information on this subject, and from a mass of statements, given in many cases with strong corroboratory details, there may be taken apparently veracious records of two toads that have occupied dooryards in two different towns for twelve and twenty-three years respectively. The histories of these toads have been given me by people of unqustionable veracity, yet I hesitate to present the records as facts, since from the evidence offered I cannot feel positive that the identity of the toad in either case has remained unchanged. There can be but little doubt that toads live to a considerably greater age than is supposed and we may hazard the opinion that many of them reach an age of at least ten or fifteen years."

FEEDING HABITS.

Particularly in the dry climate of Montana, toads are seldom seen during the sun-lit hours of the day. That they occur here, however, is known to all observing people.. In the spring of the year they may be found in large numbers in ponds and pools.

The toad takes only living, moving animal life as food. Dead food is rejected. Motionless living food is likewise rejected as has been observed by the writer and other authors. Insects that "play 'possum" and remain motionless are not taken by the toad.

Unlike the tongue of most other vertebrates that possess this organ, that of the toad is attached only at the anterior end where it is fastened to the floor of the mouth. It is coated with an adhesive substance that causes insects to adhere when touched by it. By a

very quick motion the tongue leaves the mouth, touches and picks up the food, and returns. So quick is the motion that the eye can scarcely follow it.

While out on their foraging expeditions these animals show interesting traits. Mr. Kirkland observed eight good-sized toads seated under an arc light engaged in picking up insects, which, deprived of their wings, fell from the lamp above. A physician in Malden, Dr. Charles Burleigh, observed that a colony of some half dozen toads made their abode under his piazza, and each summer night about eight o'clock went forth down the walk and into the street where they stationed themselves under an arc light. Here they fed upon the insects that fell from the lamp until the electric current was turned off when they returned to their accustomed shelter. From his observations, Mr. Kirkland concluded that under ordinary conditions toads feed continuously throughout the night except where food is abundant. He observed that in twenty-four hours the food consumed was equal to four times the stomach capacity.

It would be interesting to follow in detail the results of Mr. Kirkland's examination of the stomach contents of 149 toads but we must abbreviate and summarize.

Various investigators have shown, and it is a matter of common observation, that the toad takes pretty much any living animal food that crosses its path, provided it is not too large to be swallowed whole. It follows then that in various parts of the country the diet of the toad will be determined largely by what are the common insects found on the ground and low-growing vegetation, where the toad can reach them. The following table by Mr. Kirkland shows the results of the examination of 149 stomachs contents, in Massachusetts. Were such a study to be made in Montana the general character of the food would be the same but in detail it would be very different.

Unidentified material	5 per cent.
Gravel	1 per cent.
Vegetable detritus	1 per cent.
Worms	1 per cent.
Snails	1 per cent.

Sow-bugs	2 per cent.
Myriapods	10 per cent.
Spiders	2 per cent.
Grasshoppers and crickets	3 per cent.
Ants	19 per cent.
Carabids	8 per cent.
Scarabaeids	6 per cent.
Click beetles	5 per cent.
Weevils	5 per cent.
Chrysomelids	1 per cent.
Carrion beetles	1 per cent.
Miscellaneous beetles	1 per cent.
Total beetles	27 per cent.
Cut worms	16 per cent.
Tent Caterpillars	9 per cent.
Miscellaneous larvae	3 per cent.
Total cut worms, caterpillars, etc.	28 per cent.

The gravel and vegetable detritus were doubtless taken by accident in the rapid stroke of the tongue with which the food is taken into the mouth. It may, however, be of some value in grinding up the food, though it is not always found in the stomach. Of the total food 98 per cent is animal and by far the greater part of this is insect life.

In this brief account we will not discuss each of the items in the above table, but we would call attention to the large proportion of grasshoppers, ants, scarabaeids, click-beetles, weevils, chrysomelids, cut-worms, tent caterpillars, and miscellaneous larvae all of which are for the most part injurious.

THE AMOUNT OF FOOD THE TOAD EATS.

When in the presence of abundance of food the toad eats a very large amount. Mr. F. H. Mosher of Massachusetts fed between thirty and thirty-five full grown celery worms to one toad in three hours time. Mr. J. E. Wilcox, an employe of the Gypsy Moth Committee of the Massachusetts State Board of Agriculture, before that committee was abolished and its work abandoned, fed to a toad of medium size twenty-four fourth molt gypsy moth larvae, all of

which were swallowed in less than ten minutes. Mr. Kirkland found in a single stomach the remains of twenty-seven myriapods, in another fifty-five army worms, in another sixty-five gypsy moth caterpillars and in another thirty-seven tent caterpillars.

It is not possible to make even an approximate estimate of the financial equivalent of the saving to crops brought about by the toad, but the foregoing facts are enough to remove any shadow of doubt that this humble animal is of great value to the gardiner, florist, fruit-grower and general agriculturist.

THE TOAD SHOULD BE PROTECTED AND FAVORED

The wanton destruction of toads by ubiquitous boys is known to all. It is not an uncommon thing for a party of boys to organize an expedition to nearby ponds for the express purpose of killing toads. Dr. C. F. Dodge, published in the Worcester (Mass.) Evening Gazette, March 31, 1897, an account of finding in a single day two hundred dead or wounded toads on the shores of a pond on the grounds of Clark University.

We should not blame the boys alone for this, the parents and school authorities are in a measure responsible for this worse than useless taking of life. Rightly trained and directed the boy can get more real pleasure, and at the same time a pleasure that is infinitely better for him, by observing the habits of toads and other animals.

The toad is as deserving of protection by legislation as are insectivorous birds. The asthetic, to be sure, is lacking, but the asthetic side of the question is not the one that prompts us to enact laws that make it a misdemeanor to kill birds. It is the economic, and on an economic basis the toad is as deserving as almost any bird.

A MANUAL OF FRUIT PESTS WITH REMEDIES.

In this manual we purpose to present in condensed and easily accessible form the most essential information regarding the more important insects and fungus diseases that have been recognized in the state or which are liable to appear at any time. It is our intention at an early date to prepare another manual similar to this but dealing with farm, garden and lawn pests.

The reader should freely consult the index in seeking the information he desires. All insecticides and fungicides recommended are discussed at the end of this section, and formulae for their preparation are given.

Unless the fruit-grower is confident that he knows the pest he is dealing with he should send examples to the Experiment Station for identification.

INSECTS INJURIOUS TO THE APPLE.

1, The Red-humped Apple Tree Caterpillar.

Bright colored caterpillars with a red hump on the back, feeding on the foliage of apple. Seldom very abundant.

Remedy.—Remove by hand or spray with an arsenical poison.

2, Tent Caterpillars.

Hairy caterpillars with a bright bluish stripe down the middle of the back. Living on wild and cultivated cherry and on apple in the spring of the year. They construct tents or nests in the crotches of limbs from which they venture and feed during the middle of the day.

Remedy,—Remove the tent by hand, taking care to do so when the caterpillars are home. Under some conditions it is feasible to locate and destroy their eggs during the winter. The eggs appear as thickened bands on small twigs. Individual eggs are cylindrical and in the cluster are placed on end, side by side.

3, The Bud Moth.

Brownish caterpillars with black heads, feeding in the opening buds of apple, pear, blackberry, raspberry, and other plants in the spring of the year. Sometimes very injurious to apple, destroying the fruit buds, and by eating out the terminal-growing shoots, causing a bushy appearance of the side buds and giving the tree an unnatural appearance.

Remedy.—Keep the buds coated with an arsenical poison in the spring of the year.

4, Canker Worms.

Not yet found in Montana. Appearing soon after the foliage is expanded in the spring. Rapidly devouring the foliage or turning it brown. Whole orchards may be seen to be of a brown color at a distance, as a result of the attacks of this insect. When an infested limb is jarred the slender caterpillars, about three-fourths of an inch long let themselves down by silken threads,

Remedy,—Spray promptly and thoroughly with an arsenical poison as soon as their presence is first detected. In regions where they are suspected to be present it is well to keep the trees banded with building paper and smeared with an adhersive substance which may be watched in the spring of the year for the purpose of learning whether or not the wingless moths are ascending the trees to lay their eggs. A large proportion of the damage may be averted by the use of such bands. "Bodlime," sold by the Bowker Insecticide Co., Boston and Cincinnati, is a good adhesive substance to use for this purpose. Tar or printer's ink may be used but are less satisfactory.

5, The Codling Moth.

The larva is known as the apple worm and infests a number of fruits, but is most injurious to apple and pear. It is probably the most important pest with which the Montana fruit-grower has to deal.

Remedy.—Spray with Paris green, arsenate of lead or arsenite of lime after the petals have fallen, again two weeks later, again the first week in August. If it is not yet in your orchard, watch for its appearance by searching for wormy fruit among the wind-falls

and when harvesting the crop, and if the pest is found, begin spraying the next season. Do not bring to your orchards second-hand boxes from fruit dealers in town; it is against the laws of the state and you are liable to prosecution. Such a practice will almost surely result in the establishment of the pest in your orchard.

6, The Web-worm.

Colonies of hairy caterpillars living in tents on fruit and shade trees in the latter part of the summer and early fall. Affected limbs are enclosed in nets and the leaves are brown.

Remedy.—Remove the caterpillars by hand.

7, The Flat-Headed Apple-tree Borer.

Fairly common on apple trees in western Montana. Preferably attacks diseased or weakened trees and feeds in the larval stage in the trunk and larger branches, excavating irregular cavities under the bark and later boring into the deeper parts of the tree. It may often be detected by sunken or discolored patches in the bark.

Remedy.—Not an easy insect to combat. Practice clean culture. Dig up and burn worthless trees that are infested. In some cases it is advisable to locate the burrow of the borer and dig out the grub by means of a sharp knife or wire or other suitable instruments, taking care not to injure the tree more than necessary. Use deterrent washes.

8, The Round Headed Apple-tree Borer.

Large, legless borers in the trunks of apple trees near the ground. The anterior end of th body is of about the same diameter as the posterior part.

Remedy.—Treat as for flat-headed borer.

9, Apple Twig-borer.

Small, cylindrical, mahogany-colored beetles about one-third of an inch long, boring holes in twigs of apple, pear, cherry and other trees and in grape vines.

Remedy.—Prune off and burn infested stems.

10, Leaf-hoppers.

Small soft-bodied insects with sucking mouth parts, on the under side of the foliage of apple and other fruits. Another species is known on pear, still another on rose.

Remedy.—Spray the under side of the foliage with kerosene emulsion early in the season before the insects acquire wings and are able to fly.

11, Buffalo Tree-hopper.

Greenish or brownish three-cornered insects which make longitudinal slits in the bark of apple, laying their eggs in the slits.

Remedy.—Prune off and burn affected twigs, practice clean culture, keeping out all weeds and unnecessary vegetation.

12, Woolly Aphis of the Apple.

May be detected by the whitish woolly masses on the water-sprouts at the base of the tree and on old scars on the trunk and limbs. The colony masses are made up of the bodies of the lice and cottony secretion produced by them. The most injurious form of the insect feeds on the roots of the trees.

Remedy.—For the areal form use strong kerosene emulsion early in the season. For the root form dig away the earth down to the roots and soak with hot water and return what has been removed.

13, The Apple Leaf-aphis.

Dark-green lice on the leaves of apple, causing them to curl. Common throughout the state. More abundant on young trees.

Remedy.—When only a few terminal branches are affected, dip the affected parts into a pail of kerosene emulsion. One part in nine of water, or whale-oil soap solution, one pound in eight gallons of water. Early in the season it is well to single out individual affected trees and spray with one of the above solutions.

14, The San Jose Scale.

An insect which has caused great destruction in the United States but which would probably be much less injurious in Montana. Minute circular scales on the bark of practically all our common fruit and shade trees. When abundant, giving the trees the appearance of being coated with a layer of ashes.

Remedy.—Spray with lime, sulphur wash when trees are dormant.

15, The Oyster-shell Bark-louse.

Brownish scale insects, one-twelfth of an inch long, elongated

in form, occurring on various plants but mostly on apple, on which it is most abundant at the ends of the twigs.

Remedy.—Watch for the exceedingly minute whitish larvae early in June and when they appear spray with kerosene emulsion, one part in nine of water. Repeat in a few days if more larvae are seen.

16, Putnam's Scale Insect.

This insect occurs sparingly in western Montana. Resembles the San Jose scale, being a degraded form of life that lives under a very inconspicuous scale closely adhering to the bark.

Remedy.—If necessary to treat for this, wash with strong whale oil soap solution while the trees are dormant.

17, The Scurfy Bark-louse.

A white scale insect on the bark of apple, pear, currant and other rosaceous plants.

Remedy.—Watch for the young to hatch early in June and spray with kerosene emulsion, one part in nine of water. If necessary spray again ten days later.

18, Mealy Bug on Apple and Pear.*

Occurs in the vicinity of Missoula. White cottony or mealy masses around the buds in the spring. Found in the winter under the scales of bark. Has been reported as injurious to young trees.

Remedy.—Use whale-oil soap or kerosene emulsion as strong as the trees will stand. In the winter search for and destroy the cottony masses on the trunks of the trees, using whale-oil soap as a wash.

19, Ants as Fruit Pests.

We have received reports of ants as being injurious to young friut trees, building their mounds at the bases of the trees and eating off the bark and girdling the trunk. We have also known ants to be injurious to apple trees by gnawing the buds in the spring of the year.

Remedy.—Pour bi-sulphide of carbon into the colonial mounds; from one to five or six tablespoonfuls should be enough. This substance must not be put close to the trunks of apple trees.

Phenacoccus sp.

20, Grasshoppers.

Young grasshoppers sometimes crawl up the trunks of trees and devour the foliage. Later when they acquire wings they fly into the trees.

Remedy.—Spray the foliage heavily with arsenate of lead. To prevent the young from ascending the trees; tie belts of cotton about the trunk or smear printer's ink or some other adhesive material on a band of paper on the trunk.

21, The Clover Mite.

Giving the leaves of apple and other trees a whitish devitalized appearance. In the fall of the year and during the winter masses of very minute reddish eggs may be found on the trees, particularly in the crotches. The mites sometimes become annoying on lawns and in dwellings by crawling through the windows.

Remedy.—Spray affected trees with the 1-1-4 formula of lime-sulphur wash in the fall or early spring, while the trees are bare of leaves. Spray with kerosene emulsion to destroy the pest in the vicinity of the house.

INSECTS INJURIOUS TO THE PEAR.

22, The Pear-leaf Blister-mite.

Generally distributed in Western Montana. Causing thickened reddish spots and blotches on the leaves of pear; later in the season the spots die and turn brown, sometimes causing the foliage to drop prematurely. Serious on individual trees but does not spread very rapidly.

Remedy.—To prevent spreading, gather and burn the fallen leaves from invested trees. Spray in the spring before the buds open with the 1-1-4 lime-sulphur wash.

23, The Pear Slug.

Injurious to the leaves of pear, plum and cherry. Slimy slugs on the upper side of the leaves, eating off the surface parts, leaving the under surface and the network of veins, which later turn brown, giving the parts of the tree affected a brownish appearance.

Remedy.—Spray with arsenical poisons or dust or spray with hellebore.

INSECTS INJURIOUS TO CHERRIES.

24, The Cherry Aphis.

A dark côlored aphis on the under side of the leaves of cherry. Common in western Montana. Occuring throughout the state.

Remedy.—Treat as for apple-leaf aphis.

INSECTS INJURIOUS TO THE PEACH.

25, The Peach Tree Borer.

Primarily a peach pest, but attacking also cherry, prunes and plum. Boring in the trunks near the ground, causing characteristic gummy masses to exude on peach trees. The injury is most apparent in the spring.

Remedy.—A difficult pest to control. Keep the trees well fed and in a healthy growing condition. Prof. Slingerland has recommended the use of gas-tar smeared on the trunks to prevent the moths from depositing their eggs, and in combination with this the digging out method to destroy such larvae as gain access to the trees.

26, The Peach Twig Borer.

Though not yet found in Montana, it may turn up at any time. Reddish pink caterpillars boring in the young tender twigs of peach, plum and prune in the early spring, later feeding in the fruit near the pit.

Spray with strong kerosene emulsion in the winter. The oil destroys the worms by penetrating into the holes.

INSECTS INJURIOUS TO PLUMS AND PRUNES.

27, Plum Gouger.

Small beetles, about a quarter of an inch in length, of a leaden gray color with a yellowish head and thorax, eating pinholes in growing plums. The larva of grub feeds in the pit, later eating its way out through the pit and flesh of the plum just as the fruit matures. Attacks only American varieties.

Remedy.—Jar the trees early in the morning or in the evening when the trees are in bloom and the fruit is setting, catching the beetles that drop on a sheet spread underneath. A few beetles are able to do a great damage. Prof. Gillette found that a single female

lays as many as 450 eggs. Gather and destroy all the stung plums before the grubs escape. Spray heavily with arsenate of lead before the blossoms are out.

28, The Plum Curculio.

The beetles make a crescent-shaped slit on the fruit of the plum. The larva feds in the young fruit causing it to drop. Said to be in the Bitter Root valley.

Remedy.—Spray thoroughly with arsenical insecticides before the leaves open. Jar the trees in the early morning catching the beetles on canvas or a sheet and destroying them by burning or cruching. Promptly gather and destroy fallen fruit.

29, Plum Aphis.

Numerous pale-green lice on tender shoots of plum. Common in Montana, sometimes injurious.

Remedy—Treat as for apple aphis, but use extra precaution as the plum foliage is much more liable to be injured by insecticides.

30, The Box Elder Plant-bug.

Sometimes very injurious to foliage and fruit of plum and prunes. Feeds primarily on box elder. Red and black bugs with a long, jointed snout

Remedy.—Spray with kerosene emulsion to kill the young insects. It is sometimes necessary to remove neighboring box elder trees for the sake of doing away with the breeding place of the insects.

INSECTS INJURIOUS TO THE STRAWBERRY.

31, The Strawberry Leaf-roller.

Generally distributed in Montana, and at times a destructive species. Feeds on strawberry, blackberry, raspberry and other plants. Rolls or crumples the foliage. Larvae small, greenish in color.

Remedy.—After harvesting the crop, mow the vines, leaving them to dry. Then burn them. If there are enough vines to burn well first put some hay or straw over the field. If preferred vines may be sprayed with arsenate of lead after harvesting the fruit.

32, The Tarnished Plant-bug.

Common throughout the state. Native to Montana, feeding on many wild plants. About one-fourth of an inch in length, variable

in color, but usually marked with yellow, black and brown. Flies when disturbed. Most injurious in the spring of the year when they attack tender shoots and opening buds. Most commonly known in Montana as an enemy to blossoms and young fruit or strawberry and to young trees in the nursery row.

Remedy.—It is not always easy to control this insect. When found on young fruit trees, jar them off in the cool of the day into some receptacle which contains kerosene oil.

33, Strawberry Root Weevil.*

Small hard beeties with an elongated snout which feed on the foliage of strawberries in the early summer The larvae feed on the roots and are very injurious.

Remedy.—Delay the planting of the new crop until the beetles have deposited their eggs. Keep the foliage coated with arsenate of lead in the early part of the summer.

34, Strawberry Crown Borer.

Small yellowish white grubs boring in the crown of plants during the summer. A species which though not yet recognized in Montana is liable to be introduced at any time on imported plants.

Remedy.—In a field that is known to be infested do not allow the plants to become very old but start a new bed at some distance from the old one; burn over the patch as for the strawberry leaf-roller.

INSECTS INJURIOUS TO CURRANTS AND GOOSEBERRIES.

35, Native Currant Saw-fly.

Pale-green larvae which appear in the latter part of June or early in July and very rapidly devour the foliage of gooseberry and current bushes. The second brood appears about three weeks later. Shows preference for gooseberry.

Remedy.—Dust the bushes with powdered hellebore or spray at the rate of one pound to a gallon of water. Be prompt in the treatment and do not allow them to defoliate the bushes.

36, Currant Flies.

Maggots feeding the fruit of the currant, causing here and there

*_Otiorhynchus ovatus_ Linn.

a berry to turn red prematurely; in severe cases causing the entire crop to fall to the ground.

Remedy.—Either gather the fallen fruit frequently and destroy it, or, after all of the insects have dropped to the ground, turn with a plow a deep furrow of earth against the row, then with a rake or shovel smooth the earth down around the bushes so as to cover up the hibernating insects so deeply that they cannot escape. This should be done in the fall or early spring.

37, The Currant Stem Borer.

Larvae of a clear-winged moth, a near relative of the peach borer, which makes burrows in the currant canes, sometimes becoming very injurious.

Remedy.—Watch the currant bushes in the early part of the summer about the time the fruit is setting and cut out and burn affected canes which may be detected by the yellowish color or wilted condition of the foliage.

38, Currant Leaf-hopper.

Minute whitish insects on the under side of foliage of currant in the early part of the season. Later they acquire wings and have pinkish markings.

Remedy.—Spray the under side of the foliage with kerosene emulsion, one part in nine of water in the early part of the season.

39, The Currant Aphis.

Green lice on the under side of currant leaves, causing the leaves to turn reddish in color and to have an irregular surface.

Remedy.—Spray with kerosene emulsion or whale-oil soap solution. This spray kills only by coming in contact with the lice, therefore direct it against the under side of the leaves.

40, Currant Thrips.

Minute reddish insects of elongated form which cluster on the tender buds and blight them.

Remedy.—Pick off and destroy the affected parts.

41, Currant Cottony Scale.

Cottony masses on the canes of currant and gooseberry.

Remedy.—Spray with whale-oil soap solution, 1 pound in 4 gallons of water during the winter. In gardens where it is possible wash off the cottony masses with a strong stream of water.

42, The Gooseberry Fruit-worm.

A near relative of the codling moth which feeds in the gooseberry fruit, causing it to prematurely turn color and later to drop off. Several berries are often bound together. Common in the fruit-growing sections of the state.

Remedy.—Carefully go over the bushes and pick off the affected berries and destroy them before the worms leave. Do this at least twice in the season.

FUNGUS DISEASES.

1, Black Spot, or Apple Canker.

This is peculiarly a northwest disease and attacks only the apple. It is said to occur in western Montana. The disease is confined to the bark and produces characteristic brownish or nearly black spots. The spores are distributed during the early fall.

Remedy.—Under some circumstances relief may be secured by cutting out the affected parts. Since the disease spreads from November 1st to February 1st, it is evident that trees should be coated with a fungicide during this period. On account of frequent storms however, it would be difficult to keep a fungicide on the trees.

2, Crown Gall.

Various plants, including apple, almond, apricot, blackberry, cherry, chesnut, English walnut, grape, peach, pear, plum, raspberry, and poplar are affected with abnormal growths on the roots which have been called crown-gall. These galls vary from a size as big as a fist or larger down to very small excrescences on the fine roots. Whether or not all of these trees are affected with the same organism is not clear. A serious trouble on apple in Montana. Irrigation seems to favor its development.

Remedy.—Do not plant affected trees. Examine the roots of all new stock and discard any that shows even the slightest sign of this disease.

3, Apple Scab.

Attacks leaves and fruit and sometimes also the twigs. Circular smoky spots on the fruit which interfere with its development. Spots begin to appear when the fruit is about half grown. They

may be as large as a dime, but are usually smaller. On the leaves the fungus appears as dark olive green spots which do not have a distinct border line and occur mostly on the upper side fo the leaf.

Remedy.—Spray with Bordeaux mixture three times and ammoniacal copper carbonate (cupram) twice. First spraying of Bordeaux should be applied just before the blossom open, the second just after the petals fall, the third about ten or twelve days later. The two sprayings of cupram should follow the Bordeaux at intervals of two weeks. Bordeaux is not used in the last two sprayings since it causes the fruit to russet.

4, Pear Scab.

So similar to apple scab that no separate account is necessary.

Remedy.—Treat as for apple scab.

5, Pear Blight or Fire Blight.

Attacking individual limbs of pear, and occasionally apple and quince also. Rapidly spreading until the whole tree may be involved. The foliage turns suddenly brown as if by fire and an examination under the bark shows a fermented condition. This disease is believed to be distributed by insects that visit the flowers, as well as by other means.

Remedy.—Cut out the disease as soon as it appears and prune again whenever necessary. Always cutting below the point where the disease is reached. It is usually best to cut at least a foot below the point where the disease appears to end.

6. Gooseberry Mildew.

This troublesome disease usually appears in the spring upon the developing buds and leaves, first showing as a sparse cob-webby coating, which later develops into a denser white, powdery coating. The young berries are also attacked. A serious disease which very much interferes with the growing of choice foreign varieties.

Remedy.—Spray with potassium sulphite at the rate of one-half ounce to one gallon of water, making the first application as soon as the leaves begin to unfold, repeating the operation at entervals of one to three weeks. The ammoniacal solution of copper carbonate would probably be equally effective.

INSECTICIDES AND FUNGICIDES.

Arsenate of Lead.

This valuable insecticide is rapidly coming to the front as a safe and reliable arsenical poison. It can be applied to the foliage in any desired strength without injury, and when applied remains through rain storms. Its white color may be detected on the leaves thereby serving as a guide in its application. It is made by the union of acetate of lead and arsenate of soda, both being soluble in water. It is no longer necessary for the user to make his own arsenate of lead for it is now being sold at reasonable prices by the Bowker Insecticide Co , Boston, Mass., and Wm. H. Swift, Boston, Mass.

Paris Green.

Paris green is an old, well-known arsenical insecticide. It was first brought to prominence in connection with the war that was waged against the Colorado potato-beetle in the western states between 1860 and 1870

In spraying with this substance a hot day should be avoided if possible, especially if it is desired to apply nearly to the limit of what the foliage will stand without injury. The water on the foliage soon becomes warmed and when warm dissolves the Paris green more rapidly, thereby resulting in injury to the leaves.

Arsenite of Lime.

The desire for a reliable and cheaper arsenical insecticide has led to the employment of a product resulting from the union of freshly slacked lime and commercial white arsenic. The proportions are:

Commercial white arsenic	1 pound.
Unslacked lime	2 pounds.
Water	2 gallons.

Boil together for twenty minutes to half an hour. As soon as the arsenic is dissolved it is precipitated by the lime as insoluble arsenite of lime. There is danger however that not all the arsenic will be precipitated out as it is difficult to tell when all has been

dissolved. For this reason the following formula is considered much more reliable:

White arsenic	2 pounds.
Sal soda	4 pounds.
Water	2 gallons.

Boil for about fifteen minutes or until all is dissolved, leaving a clear liquid. Add water enough to replace what has boiled away to prevent chrystalization of the arsenite of soda. A large quantity may be prepared at one time and kept as a stock solution to be used when desired. It should be covered to prevent evaporation and plainly labeled for it is a deadly poison. One pint of this stock is approximately equivalent to four ounces of Paris green. It should be used only in a solution in which lime is present for, as seen above, it is soluble in water. With lime it forms arsenate of lime which is the resulting product of the previous formula. It may also be used in connection with Bordeaux mixture, in which case Bordeaux mixture is used as a diluent in place of water.

Counting the cost of the preparation of arsenite of lime it is not probable it will be found cheaper unless large quantities are to be used. In using this substance in preference to Paris green, however, one avoids the danger of purchasing adulterated goods.

Hellebore.

Hellebore has a narrow range of usefulness and is effective chiefly against saw-fly larvae. It kills by coming in contact with soft-bodied insects or by being eaten. It is usually dusted on the foliage either pure or mixed with twice its amount of lime, plaster or cheap flour. The foliage should be moist when it is applied in a dry form, otherwise it will not adhere. In Montana where the foliage is almost perpetually dry, it would be better to apply it as a spray at the rate of one ounce to 2-4 quarts of water. Hellebore is not poisonous to man.

Kerosene Emulsion.

Pure kerosene is fatal to almost all insects. It is extremely penetrating and enters the breathing pores of the insects and interfering with their breathing causes their death. Pure kerosene, however, is more or less injurious to plant life and for this reason has to be diluted in some way. Since it will not mix with water it is necessary to form an emulsion, and soap is usually used for this purpose.

A good formula is:

Ordinary bar soap	½ pound.
Soft water	1 gallon.
Kerosene	2 gallons.

The water is placed over a stove to heat and the soap shaved into it. When the soap is dissolved and the water has reachedd the boiling point the solution is poured into the kerosene and vigouously churned for four or five minutes with a force pump the nozzle of which is directed back into the vessel. The mixture takes on a milky appearance and on cooling becomes jelly-like. This is the stock emulsion and if properly prepared will keep for a considerable length of time, but should be diluted when used.

Whale-oil Soap.

Whale-oil soap, more correctly known as fish-oil soap, is of great value as an insecticide against certain classes of insects particularly scale insects. Some species of plant lice which fail to succumb to an application of very strong kerosene emulsion are readily killed with a solution of whale-oil soap. An example is the louse so commonly attacking spruce trees in Montana causing cone-like galls on the twigs.

Ordinary foliage will not safely stand a stronger solution than one pound in four gallons of water. Most plant lice are readily killed by 1 pound in 6 gallons of water. If a good whale-oil soap cannot be obtained a substitute may be made by the following formula:

Concentrated lie	3½ pounds.
Water	8 gallons.
Fish-oil	1 gallon.

Dissolve the lie in boiling water and add the oil to the solution still boiling. Continue to boil for two and a half hours and then allow it to cool. The fish-oil can be obtained in eastern markets and beyond doubt it would be cheaper for the fruit-grower to make his own soap provided he intends to use a considerable quantity.

Lime-Sulphur-Salt Solution.

This insecticide is used chiefly as a means of destroying the San Jose scale, but is of great value also as a remedy for many other pests. Though various formulae have been given for the preparation of this wash, the active caustic principle is the same in all. The caustic ingredient is produced by the union if the sulphur and lime. In part two of Bulletin 56 of the Washington Experiment Station by Prof. C. V. Piper and R. W. Thatcher it is shown by accurate chemical processes that, practically speaking, one part of lime causes two parts of sulphur to go into solution and that the presence of salt in the solution does not influence the action of the sulphur and lime upon each other. It follows then, that if a greater proportion of lime is used, the excess goes onto the tree merely in the form of a whitewash, and if the salt has any value it is purely a mechanical one, for salt in such a small proportion is valueless as an insecticide. We

are not prepared to say that there is not some benefit to be derived from the presence of the salt and the excess of lime and for the present we recommend the formulae given below. We suggest, however, that fruit-growers make more careful tests of the wash with the salt omitted and with the sulphur and lime in the proportion of 1 to 1. It will, of course, be understood that a variation in the amount of water used in the formulae will result in making the wash more or less concentrated according as more or less water is used.

The ingredients may be used in the following proportion:

Lime	1 pound.
Sulphur	1 pound.
Salt	½ to 1 pound.
Water	4 gallons.

While we recommend the addition of salt under ordinary circumstances, this substance is unnecessary in the treatment of pear-leaf blister mite, moreover, Prof. Piper found it to be unnecessary in treating for the San Jose scale.

Slake the lime thoroughly in a vessel, which is to be used in boiling the mixture, then add the sulphur; boil at least for one hour using enough water to completely cover the sulphur and lime. Add the remainder of the water of the formula.

Hyhrocyanic Acid Gas.

This very deadly gas is coming into common use as a means of destroying many forms of insect life that cannot be controlled with poisons or contact insecticides.

The gas is a deadly poison to all animal life and in its use great care must be taken not to inhale it. It is prepared by the action of sulphuric acid and potassium cyanide. The potassium cyanide, again, is a deadly poison and a small quantity taken into the stomach will result in death. Potassium cyanide may be obtained from Roesler Hasslacher & Co. of New York City.

The gas is used in different strengths for different purposes. The desired strength being obtained by taking a given quantity of the potassium cyanide and adding to it the required amount of sulphuric acid. For fumigation of nursery stock the proprtions used, per each cubic foot of space inclosed are:

Potassium cyanide, 0.25 grams.
Sulphuric acid, 98 per cent.
One-half more acid, liquid measure than cyanide.
Water, one-half more water liquid measure than acid.

The following is taken from Johnson's Fumigation methods:

"The amount of cyanide necessary for any inclosure is determined in terms of grams per cubic foot of space inclosed To deter-

mine the exact amount of cyanide necessary to fumigate a room, car, ship or building of any kind the cubic contents must be accurately computed. As an example: a room 20 x 30 x 10 feet contains 6,000 cubic feet of air space. To estimate the amount of cyanide ncessary for this inclosure multiply 6,000 by 0.25; thus: 6,000 times 0.25 equals 1500 grams. To reduce this to ounces divide by 28.35 as there are 28.35 grams in an ounce; thus: 1500 divided by 28.35 equals 53 ounces, the exact amount necessary for the inclosure. It is now easy to determine the amount of acid and water, as a half more acid, liquid measure, than cyanide, and a half more water than cyanide are used; thus: 53 divided by 2 equals 26.5, which added to 53 equals 79.5 ounces of acid or practically 5 pounds liquid measure. Again 79.5 or practically 80, as we usually discard fractions, equals 40, which added to 80 makes 120 ounces of water."

In liberating the acid the gas is first measured and poured into an earthenware dish, then the water is measured and poured into the acid. The potassium cyanide which has been previously weighed is then added to the acid and water after every precautionary arangement has been made. If a room is to be fumigated, a bag containing the potassium cyanide should be suspended directly above the jar with the string suspending it passing through a pulley. Then the operator from the door may release the string and allow the bag to settle into the jar. If the space to be fumigated is under a tent the cyanide may be dropped in from the hand. Close the door tightly or drop the tent quickly and leave the desired length of time. The room or the tent should be air-tight. The exposure usually employed is thirty to forty minutes.

Some horticulturists fumigate their green-houses a few times a year and are able by this means to keep down all injurious insects except the red spider. In fumigating mills, hotels, etc., it is necessary to have an arrangement for ventilating the rooms from the outside. This may be done by attaching cords to the window sashes. After fumigation, such buildings must be allowed to ventilate thoroughly before entering them. In fumigating buildings give an exposure of 1 hour to 24 hours.

Bordeaux Mixture.

We quote the following from Farmers' Bulletin, No. 38, U. S. Department of Agriculture, prepared by Dr. Galloway:

"All things considered, it is believed that the best results will be obtained from the use of what is known as the 50-gallon formula of this preparation. This contains:

Water	50 gallons.
Copper sulphate	6 pounds.
Unslacked lime	4 pounds.

It has been found that the method of combining the ingredients has an important bearing on both the chemical composition and the physical structure of the mixture. The best results have been obtained from the use of the Bordeaux mixture made in accordance with the following directions:

In a barrel or other suitable vessel, place 25 gallons of water. Weigh out 6 pounds of copper sulphate, then tie the same in a piece of coarse gunny-sack and suspend it just beneath the surface of the water. By tying the bag to a stick across the top of the barrel no further attention will be required. In another vessel slack 4 pounds of lime, using care in order to obtain a smooth paste, free from grit and small lumps. To accomplish this it is best to place the lime in an ordinary waterpail and add only a small quantity of water at first, say a quart or a quart and a half. When the lime begins to crack and crumble and the water to disappear add another quart or more, exercising care that the lime at no time gets too dry. Toward the last considerable water will be required, but if added carefully and slowly a perfectly smooth paste will be obtained, provided, of course, the lime is of good quality. When the lime is slacked, add sufficient water to the paste to bring the whole up to 25 gallons. When the copper sulphate is entirely dissolved and the lime is cool, pour the lime milk and copper sulphate solution together into a barrel holding 50 gallons. The milk of lime should be thoroughly stirred before pouring. The method described insures good mixing, but to complete this work the barrel of liquid should receive a final stirring, for at least three minutes, with a broad wooden paddle.

It is now necessary to determine whether the mixture is perfect—that is, if it will be safe to apply it to tender foliage. To accomplish this, two simple tests may be used. First insert the blade of a pen-knife in the mixture, allowing it to remain there for at least one minute. If metallic copper forms on the blade, or, in other words, if the polished surface of the steel assumes the color of copper plate, the mixture is unsafe and more lime must be added. If, on the other hand, the blade of the knife remains unchanged, it is safe to conclude that the mixture is as safe as it can be made. As an additional test, however, some of the mixture may be poured into an old plate or saucer, and while held between the eyes and the light the breath should be gently blown upon the liquid for at least half a minute. If the mixture is properly made, a thin pellicle, looking like oil on water, will begin to form on the surface of the liquid. If no pellicle forms, more lime should be added.

If spraying is to be done upon a large scale, it will be found more convenient and economical in every way to prepare what are known as stock solutions of both copper and lime. To prepare a

stock solution of copper sulphate, procure a barrel holding fifty gallons. Weigh out 100 pounds of copper sulphate and after tying it in a sack suspend it so that it will hang as near the top of the barrel as possible. Fill the barrel with water and in two or three days the copper will be dissolved. Now remove the sack and add enough water to bring the solution up again to the 50-gallon mark, previously made on the barrel. It will be understood, of course, that this second adding of water is merely to replace the space previously occupied by the sack and the crystals of copper sulphate. Each gallon of the solution thus made will contain two pounds of copper sulphate, and, under all ordinary conditions of temperature, there will be no material recrystalization, so that the stock preparation may be kept indefinitely.

Stock lime may be prepared in the same way as the copper sulphate solution. Prepare a barrel holding 50 gallons, making a mark to indicate the 50-gallon point. Weigh out 100 pounds of lime, place it in a barrel and slack it. When slacked, add sufficient water to bring the whole mass up to 50 gallons. Each gallon of this preparation contains, after thoroughly stirring, two pounds of lime.

When it is desired to make Bordeaux mixture of the 50-gallon formula it is only necessary to measure out three gallons of the stock copper solution, and, after thoroughly stirring, 2 gallons of stock lime; dilute each to 25 gallons, mix, stir, and test as already described. One test will be sufficient in this case. In other words, it will not be necessary to test each lot of Bordeaux made from the stock preparations, provided the first lot is perfect and no change is made in the quantity of the materials used. Special care should be taken to see that the lime milk is stirred thoroughly each time before applying. As a final precaution it will be well to keep both the stock copper sulphate and the stock lime tightly covered."

For trees in foliage use only 4 pounds of the blue stone to 50 gallons of water. For tender foliage like plum, cherry, and peach use 3 pounds of blue stone to 50 gallons of water (Bul. 75, Oregon Exp. Station).

Ammoniacal Solution of Copper Carbonate.

We also take this description from Farmers' Bulletin No. 38. "This preparation as now generally used, contains:

Water	45 gallons.
Strong Aqua ammonia	3 pints.
Copper carbonate	5 ounces.

The copper carbonate is first made into a thin paste by adding a pint and a half of water. The ammonia water is then slowly added, and if of the proper strength, i. e., 26 degrees, a clear, deep-blue

solution is obtained, which does not become cloudy when diluted to 45 gallons.

The ammoniacal solution of copper carbonate being a clear liquid its presence on the leaves, fruit, and other parts of the treated plant is not so noticeable as where preparations containing lime are used.

In case it is desired to keep the strong solution as a stock preparation, the bottle or jug in which it is placed should be tightly corked."

Copper Sulphate.

Copper sulphate (blue vitrol or blue stone) solution is sometimes used in place of Bordeaux mixture. It is also used as a means of destroying the spores of grain smut on seed grain, but for this purpose formalin is considered to be better.

For trees in a dormant state, use copper sulphate, 1 pound in 25 gallons of water. For trees in foliage use copper sulphate, 1 pound in 250 gallons of water.

Potassium Sulphide.

This substance, also known as liver of sulphur, may be obtained from almost any druggist. It is used in the proportion of one-half to one ounce in one gallon of water. A stock solution may be made as follows:

Potash	32 pounds.
Sulphur	37 pounds.
Salt	2 pounds.
Water	50 gallons.

The potash, sulphur and salt are put into a large, metallic tub with a part of the water; the chemical action will make the mixture boil. Add the remainder of the water and set it away as a stock solution, covering it to prevent evaporation. Dilute with 99 parts of water before spraying.

R. A. COOLEY.

EXPLANATION OF PLATES

(Photographed from Nature by R. A. Cooley except top figure of plate II, which was loaned by Prof. Slingerland from his bulletin on the bud moth, 147, Corn. Univ. Experiment Station.)

PLATE I.

Fig. 1, Egg of the bud moth, greatly enlarged.
" 2, The 5-spotted lady-bug, enlarged.
" 3, Cluster of eggs of the 5-spotted lady-bug.
" 4, Same.
" 5, Larva of the 5-spotted lady-bug, about four time enlarged.

Fig. 6, Base of apple leaf from below showing work of bud moth larva. The web and tubular retreat are indistinctly shown.

Fig. 7, Full grown larva of the bud moth, about three times enlarged.

PLATE II.

Fig. at top, Apple twig showing work done by bud moth larvae early in the season.

Fig. 1, Apple-leaf aphis on the under side of a leaf.
" 2, Terminal apple shoots showing leaves deformed by apple leaf-aphis.

PLATE III.

Fig. 1, Top view of *Sarcophaga cimbicis* Townsend, about twice natural size.

Fig. 2, Same from side.
" 3, Larva or maggot of same.
" 4, Pupa of same.
" 5, Apple leaf-aphis, enlarged.
" 6, Eggs of apple leaf-aphis, about twice natural size.
" 7, Root and base of trunk of young apple tree showing injury done by Flat-headed apple-tree borer.

PLATE IV.

Lines indicate the length of the body from front of head to tip of wings or abdomen, whichever extends farther.

Fig. 1, Lesser Migratory Locust, *Melanoplus atlanis* Riley, female.

Fig. 2, Same, male.

" 3, Big-headed Grasshopper, *Aulocara elliotti* Thomas, female.

Fig. 4, Same, male.

PLATE V.

Lines indicate the length of the body from front of head to tip of wings or abdomen whichever extends farther.

Fig. 1, Yellow-winged Locust, *Camnula pellucida* Scud, female

" 2, Same, male.

" 3, Two-striped locust, *Melanoplus bivittatus* Say, female.

" 4, Same, male.

PLATE VI.

Lines indicate the length of the body from front of head to tip of wing or abdomen whichever extends farther.

Fig. 1, *Melanoplus dawsoni* Scudder, female.

" 2, *Hippiscus neglectus* Thomas, temale.

" 3, *Chortophaga viridifasciata* DeG., female.

" 4, *Encoptolophus sordidus* Burm, female.

PLATE VII.

Lines indicate the length of the body from front of head to tip of wings or abdomen whichever extends farther.

Fig. 1, *Spharagemon aequale* Say, female.

" 2, *Melanoplus spretus* Uhler, female.

" 3, *Arphia tenebrosa* Scudder, female.

" 4, *Acrolophitus hirtipes* Say, female.

PLATE VIII.

Lines indicate the length of the body from front of head to tip of abdomen or wings whichever extends farther.

Fig. 1 *Dissosteira carolina* Linn., female.

" 2, *Cordillacris occipitalis* Thomas, female.

" 3, Egg mass of *M. bivittatus*, about three and one-half times natural size .

Fig. 4, Same with the surface removed.

PLATE I

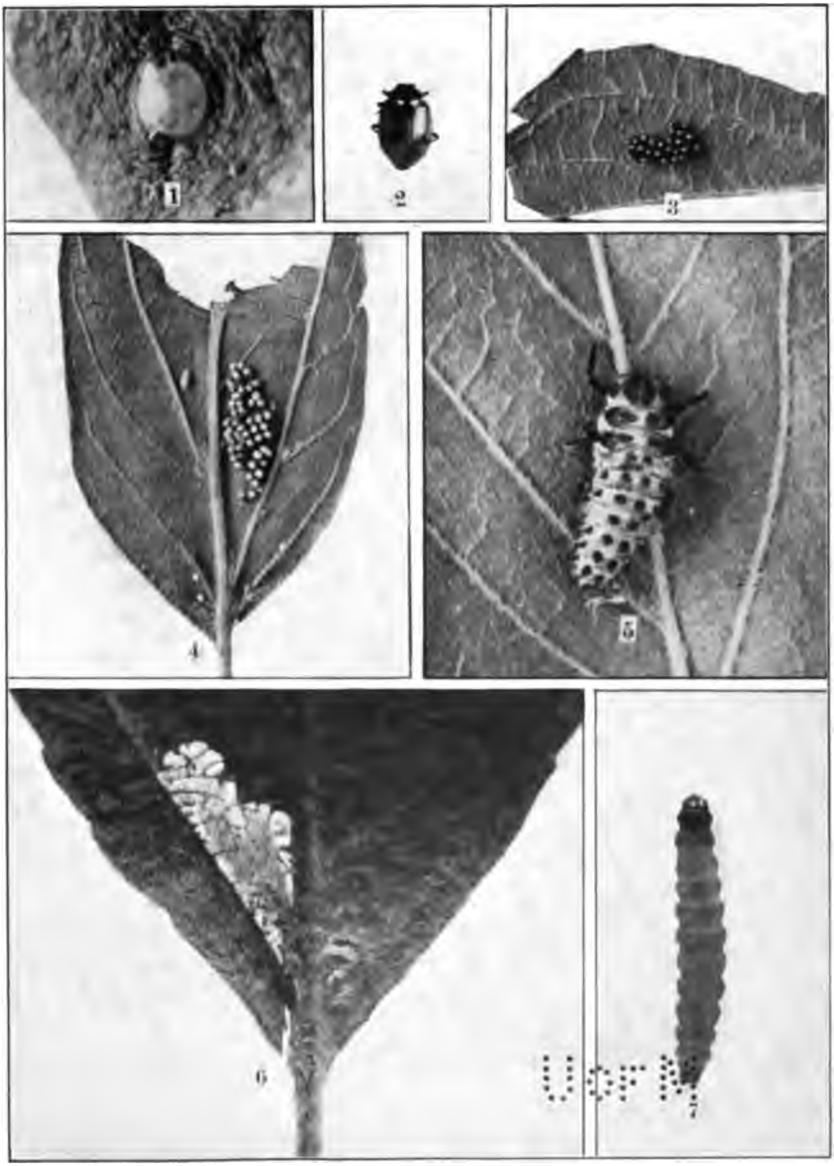


PLATE II

PLATE III

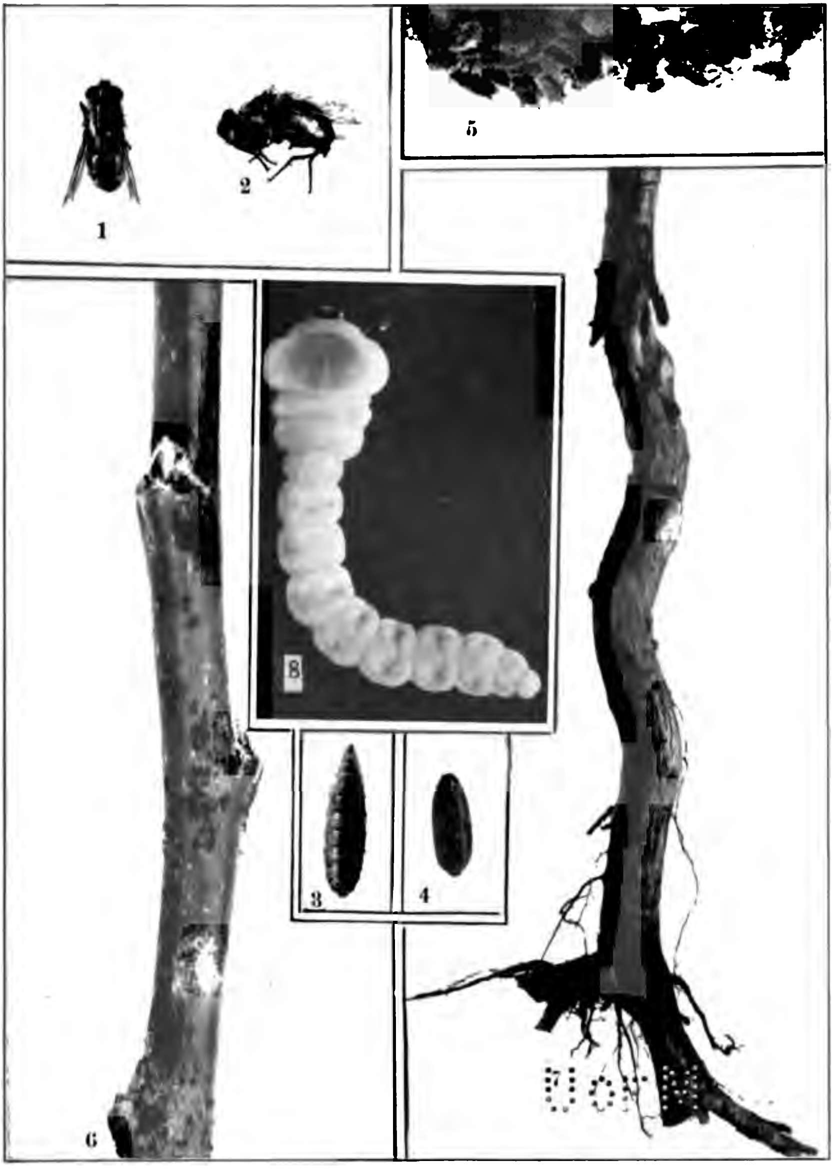
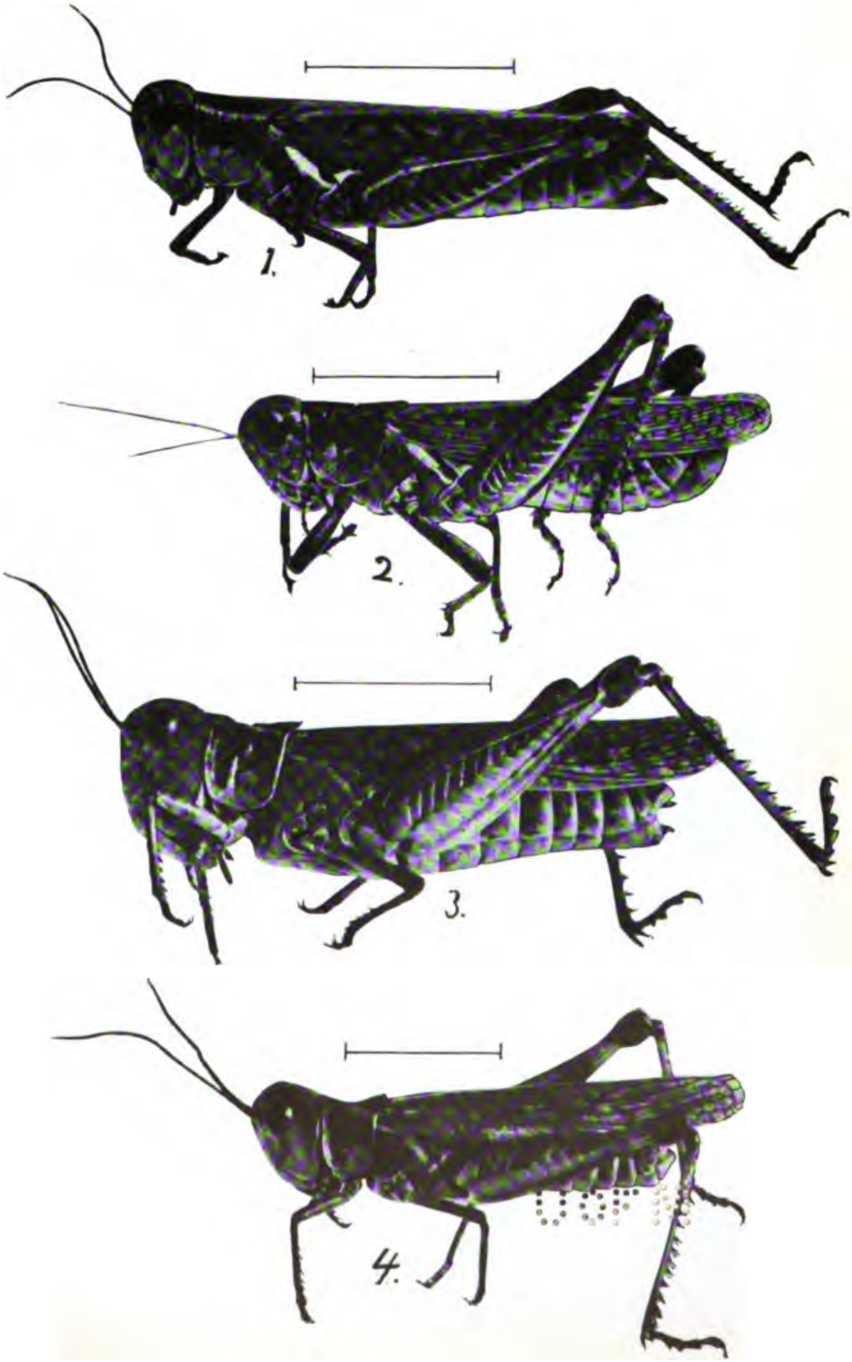


PLATE IV



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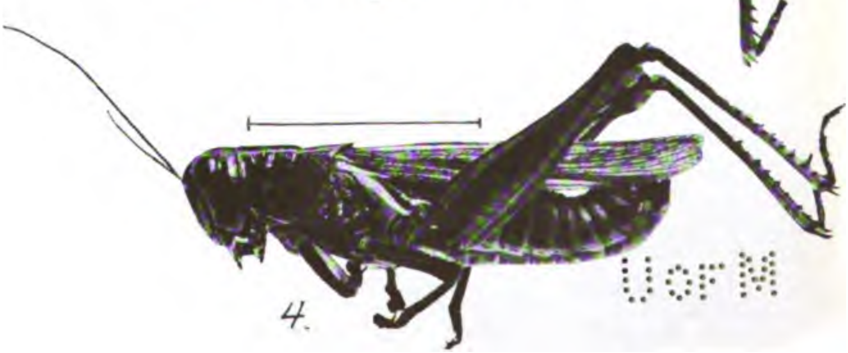

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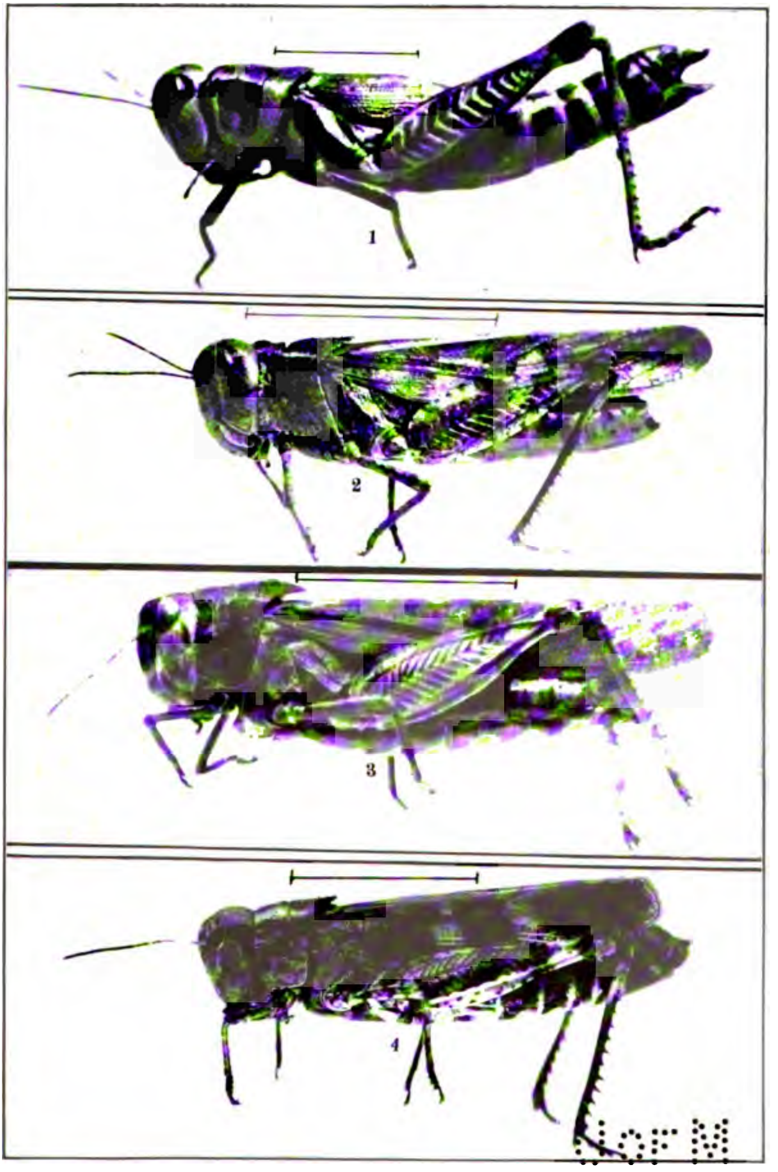

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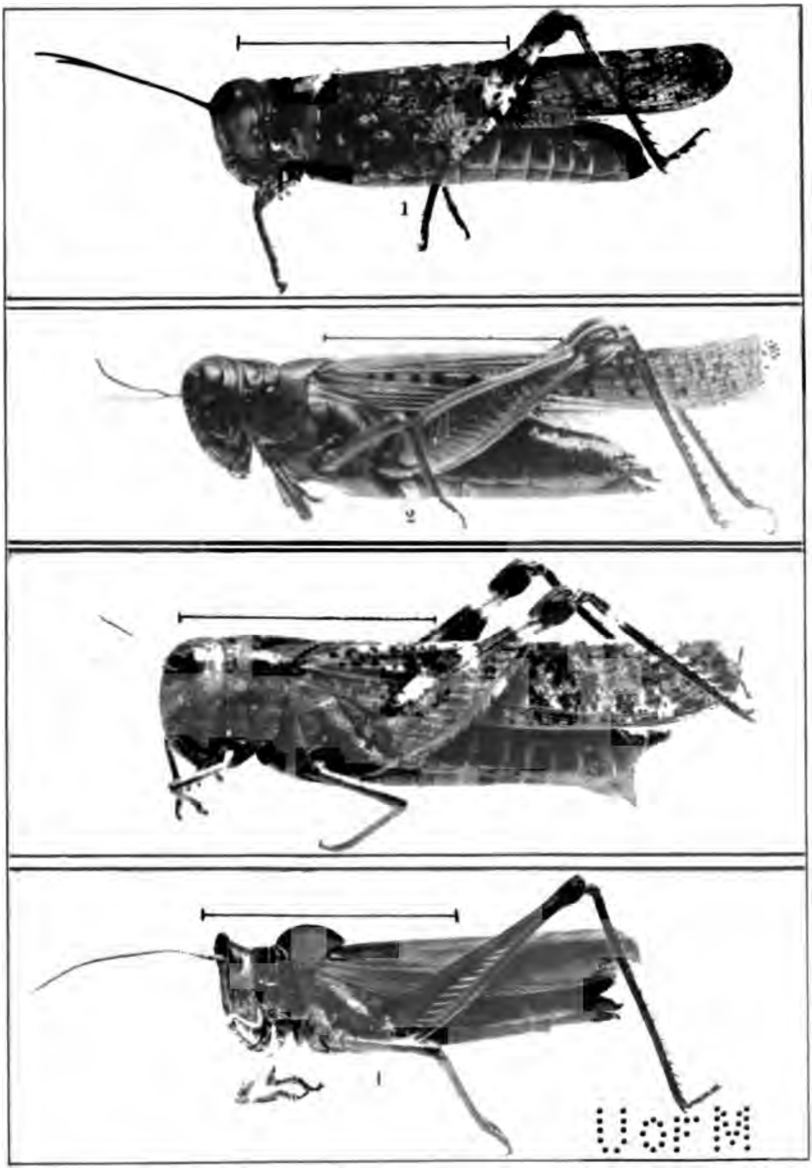

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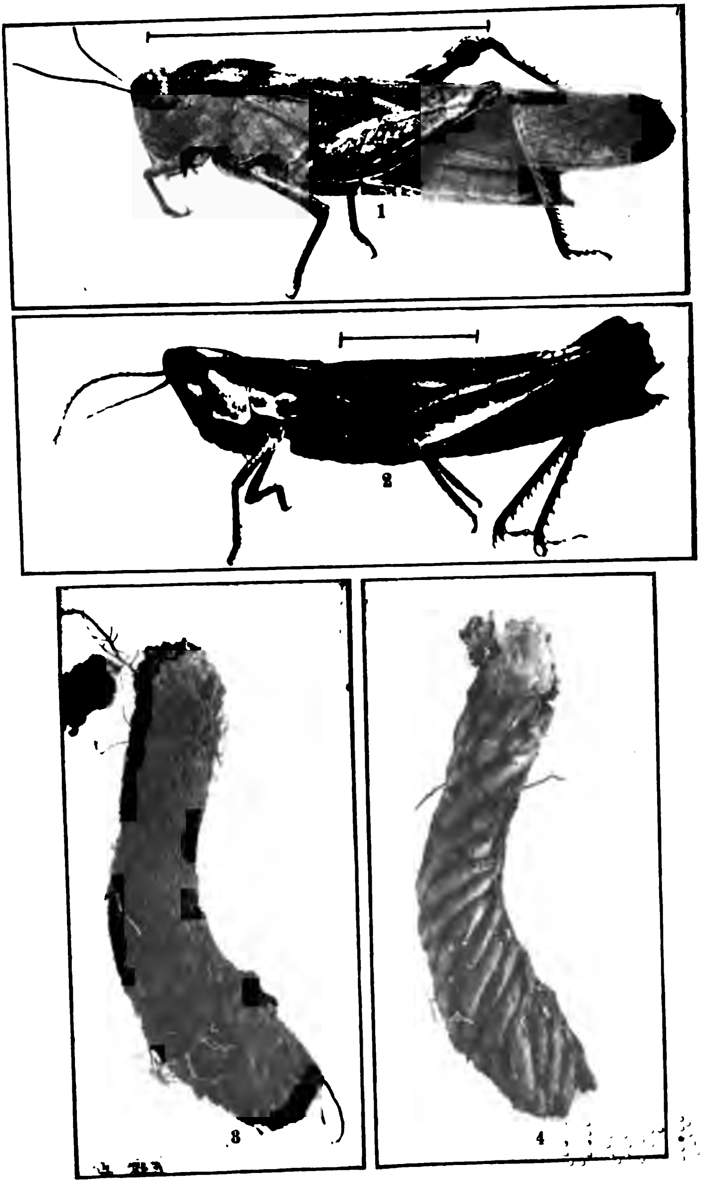

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BULLETIN No. 52,

MONTANA AGRICULTURAL

Experiment Station,

OF THE

Agricultural College of Montana.

SUGAR BEETS

Bozeman, Montana, April, 1904.

REPUBLICAN,
Bozeman, Montana,
1903.

MONTANA AGRICULTURAL

Experiment Station.

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All communications for the Experiment Station should be addressed to

THE DIRECTOR,

MONTANA EXPERIMENT STATION,

Bozeman, Montana.

Notice.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

BULLETIN NO. 52. - - APRIL, 1904.

Sugar Beets

The Crop of 1903

F. W. TRAPHAGEN

In presenting the results of the investigation of the past year, but few comments are necessary.

It has repeatedly been shown that all the conditions for the establishment of a successful beet sugar factory could be found in several localities in the state; yet for some reason Montana, abundantly able to produce all the sugar consumed by her citizens, and much more, still obtains her supply from other sources.

Other states similarly located are increasing the number of their factories annually, and all who have embarked in the enterprise, both farmers and manufacturers, are greatly pleased with the results.

In the face of the passage of the Cuban Reciprocity Act, which has been the bugbear of the beet sugar men, the price agreed upon in Colorado for the crop of 1904 is five dollars a ton, a marked advance over the price of former years.

Montana producers could count with absolute certainty upon yields at least as great as those of other states, and the richness and

purity of the product could be maintained above the usual standard with no difficulty; while, with intelligent care in culture, these figures could be much improved. This is no mere idle speculation, but is the conclusion forced upon all who study the reports of the experiments carried on under the supervision of the Chemical department of the Montana Experiment Station during the last half dozen years.

Of our neighboring states, Utah has four factories, with a capacity for handling 2,300 tons of beets per day; Colorado, nine factories, with a capacity of 6,250 tons daily; Washington, one factory, with a capacity of 350 tons; and Idaho, one factory, capacity, 600 tons.

The world's production of sugar in 1902 amounted in round numbers to 8,500,000 long tons, of which about 5,800,000 tons, approximately 60 per cent., was beet sugar.

The consumption of sugar in the United States amounts to approximately 2,250,000 long tons, about 26 per cent. of the world's entire production.

These 2,250,000 long tons of 2,240 pounds are equal to 2,520,000 tons of 2,000 pounds each, as figured in all American calculations.

Assuming that the average product of each beet sugar factory erected in the United States is 5,000 tons, it would require 500 such factories to meet this home demand. Assuming that the present established beet sugar factories and the cane mills of the South now produce 500,000 tons—too high an estimate—it would still require 400 more factories to provide for our home consumption.

The average annual increase of consumption is 6 per cent., or 151,000 tons. To meet this increase alone there would be required to be erected EACH YEAR 30 factories of this capacity, say 500-600 tons of beets per day.

TO PAY FOR THIS SUGAR NOW IMPORTED WE ARE SENDING ABROAD ANNUALLY NEARLY $125,000,000.

The American farmer is to-day raising wheat yielding an average gross return of $10 per acre, which is being sent abroad to pay for sugar which he consumes, while the same lands on which the wheat is grown would produce the sugar and yield from $65 to $100 per acre.

This is neither economy nor common sense.

It will be seen, therefore, that, in addition to the 54 beet sugar factories which will be producing sugar during the coming season of 1903-4, nearly 400 new factories of 600 tons capacity are still to be constructed before the actual home consumption of sugar and next year's increase is supplied from beets grown on American farms, manufactured by American labor, by the investment of American capital.

No industry, agricultural or mechanical, yet established or contemplated, confers a tithe of the benefits and prosperity upon the local community which has been the invariable accompaniment of the establishment of the beet sugar factory.

None even approach it in character, unless it be the canning or creamery plants, consuming the prodncts of local farmers; and these are insignificant in comparison.

Trade associations of booming towns, labor assiduously to secure the location of a new manufacturing industry whose sole value to the community is the pay roll disbursement of a few thousands per year.

To accomplish this they pay liberal bonuses and grant exemption from taxation.

In contrast with all such enterprises, the beet sugar factory is unique and unequaled as a producer of unexampled prosperity.

The location, in any community, of a beet sugar factory of a capacity of 600 tons—the most approved and economical unit—means the purchase of 60,000 tons of beets from the farmers of the immediate neighborhood, at an average of $5 per ton, and a pay roll disbursement of $60,000 per annum—a total of $360,000 paid in cash to such community during the fall and winter months.

The effect of the distribution of this enormous sum, in addition to the ordinary disbursements, may easily be conceived.

This amount distributed among the farmers, flows into every avenue of trade, leaving its profits behind, finding its way to the banks to be again forwarded on its beneficent mission, enlivening and enriching all branches of trade and assisting the establishment of new industries.

Population materially increases; town lots command a double price; farming lands are in increased demand at greatly increased prices;

bank deposits are sometimes tripled and quadrupled; debts and mortgages are paid off, and new carriages, farming implements and pianos take their places, and abundant prosperity abounds everywhere, and civilization is advanced.

This is the simple history of the industry wherever it has been established in a proper location for the growth of beets.

There are but few exceptions, and should have been none had not the zeal and ambition of the projectors overrun their judgment in the establishment of a few plants in locations partially unfit.

Requisites for Location

The following are the essential requirements of location for a successful factory:

First: BEETS, in sufficient quantity and of the required sugar content and purity. It is unprofitable to work beets containing less than 12 per cent. of sugar, and they should rather average 14 per cent. Anything above this average is so much the better.

The purity of the beet is of equal, if not greater, importance, and should be at least 80 per cent. or better. Beets of a high purity and comparatively low sugar content yield more sugar than those of higher sugar content and low purity.

By purity, or the co-efficient of purity, as it is technically called, is meant the ratio of the sugar to the solid contents of the juice.

If in 100 pounds of juice there are 15 pounds of solid matter, of which 12 pounds are sugar, the co-efficient of purity is 80 per cent., or the sugar, 12 pounds, divided by the solid matters, 15 pounds.

These beets are then said to contain 12 per cent. of sugar, with a co-efficient of purity of 80 per cent.

The remaining three pounds contain all the other mineral salts taken up from the soil, and are injurious to the extraction of the sugar, as they are chiefly molasses-forming, or melassiginic, as it is termed. One pound of these salts will prevent the crystallization, or invert, one pound of sugar.

To determine the availability of the location, soil and general conditions, extended experimental cultivation should be made, using

the best seed and following the most approved methods, having the results carefully analyzed by the State Experiment Station.

Careful analysis of the varying soils is also an advantage.

On general principles, the acreage required for a plant of any capacity should be ten times the daily tonnage capacity; for a 600-ton plant, 6,000 acres.

A trifle smaller acreage in irrigated sections might suffice, as the tonnage product is apt to be, with the proper care, neariy 50 per cent. greater.

Second: WATER. The water supply should be at all times adequate and not subject to fluctuations or failure, and as free as possible from mineral matter, for the same reason as above explained in reference to the purity of the beets.

If there be any doubt upon this point. a careful analysis should be made.

At least 3,000,000 gallons daily are required for the operation of a 600-ton factory; and the source of supply should always be reasonably near the factory site, to avoid excessive pumping apparatus and operating expenses.

Third: DRAINAGE. As the above quantity of water must be discharged from the factory heavily contaminated with soil washed from beets, with the waste lime and impurities removed from the beets and juice in the process of refining, it should not be allowed to flow into any natural water course used below for domestic purposes.

It should be impounded, if possible, in some old depression, slough, or settling basin, where the water can be allowed to drain off, when the solid matter can be used as a fertilizer for which it is especially valuable, as it contains, in a concentrated form, precisely the salts taken from the soil.

These three requirements assured, there is the most important one to mention.

This is—

Fourth: MONEY. Without this all the others are valueless so far as the establishment of this industry is concerned. To construct and properly equip a modern beet sugar factory, the cost will be approximately $1,000 per ton of daily capacity; that is, a 600-ton plant will cost about $600,000.

This first cost, however, is variable, being subject to the prevailing market rates for material and labor; the freight rates to the selected site; the character of the land in respect to drainage, water supply and railroad connections, as well as to the quality and proportions of the machinery equipment and the size and general character of the buildings provided.

The above figures will apply to a perfect plant of liberal design and ample proportions of both buildings and machinery, in which all buildings shall be of the most approved fire-proof construction.

Upon certain specifications this figure might be low, while upon others the price might be too high.

It is purely a question of what is furnished for the price charged.

This does not include the cost of railway switches, purchase of seed, or agricultural expenses, for which and for a small working capital, a further sum should be raised, varying with the conditions.

This amount of money must be fully assured from some reliable source before it is at all safe to enter into any contract for construction.

Factory Site

To the above requirements might be added the desirable qualifications for a site for the erection of a factory, viz:

A practically level tract, not less than fifteen acres in extent. A larger tract would be preferable, to proxide ample space for drainage basins, pulp pits, etc.

The situation should be as near as possible to the center of the beet-growing territory, and preferably near some town, to provide residences for operatives.

To be on or near a railroad, preferably two, to assure the delivery of coal and limestone at reasonable rates; in such a location that a right-of-way for a siding may be obtained.

There will be required about one mile of track for switches, sidings, and yard service.

Procedure to Secure a Factory

On account of the necessity for locating factories in the midst of

the sugar beet fields, usually in farming communities, local capital is either lacking or not to be had in sufficient amount to carry through the enterprise. Outside capital must generally be secured for the purpose.

To interest and obtain such assistance, any community must first demonstrate, by indisputable proofs, that the location proposed fully answers all the requirements above enumerated; but first and foremost, that it has the necessary acreage contracted for, or that it can certainly obtain such contracts when the other preliminaries are arranged.

Having conclusively demonstrated the adaptability of the section for the production of beets rich in sugar and of high purity; having interested the farmers to a willingness to contract for the necessary supply of beets; determined upon an advantageous and suitable site, the next business is the procurement of the capital.

Some considerable local capital must be invested to inspire in others confidence in the local interest. management and support.

Let the most influential men in the community start a preliminary subscription to the capital stock of the proposed sugar company.

In the preparation of this work, take the advice of the best attorney in the community.

The capitalization of the company should be sufficiently large to cover the cost of the plant and at least $50,000 additional for working capital.

This may be entirely in capital stock, or part stock and part bonds.

In such communities there is frequently a prejudice against the mortgaging of the property as security for a bond issue, which is but a representation of such mortgage divided into smaller parts.

This is a mistaken notion and contrary to the practice of the best financiers whenever any enterprise will earn a larger amount in dividend than is necessary to be paid in interest on money hired.

The farmer himself recognizes this principle when he hires money at 5 or 6 per cent. on a mortgage of his original farm in order to increase his earning power far above the interest charge.

To illustrate the difference, let us suppose a sugar company capitalized at $600,000 in stock alone, and the net earnings to be 20 per cent., making $120,000.

If, on the contrary, the capital stock were $300,000, and the other $300,000 of capital was realized on a bond issue of 5 per cent., the interest charge on the bonds would be $15.000, leaving $105,000 of the earnings as a dividend on $300,000 of stock, amounting to 35 per cent. instead of 20 per cent., as in the other case.

As every merchant, trader, banker, land owner or farmer in the community cannot fail to derive direct benefit from the sugar factory enterprise, all should assist it by liberal subscription to the stock, aside from the handsome dividends to be anticipated from such an investment.

When $100,000 to $150,000 has been assured by local subscription or through local influence, the company should be legally incorporated and correspondence opened with some reliable construction company or builder for further advice or assistance, which most of them are able to give.

Cost of Operation

The cost of the operation of a beet sugar factory is dependent in a great measure upon the character, capacity and arrangement of the machinery and apparatus. Compactness and convenience of arrangement are conducive to a saving of labor. The same feature, with straight piping and shortest possible lines curtails friction and saves fuel. Ample capacity, in proper proportions, with scientific by-pass arrangements, avoids delays and difficulties.

Proper arrangement and connections, and proper utilization of live and exhaust steam, hot water and wash waters, save labor, fuel, sugar and money.

A well designed and arranged factory can be easily operated by 175 to 180 men, in day and night shifts of not over 90 men each, exclusive of the superintendent.

For the purpose of a conservative estimate, however, it is set at 200 men.

The following may be considered a safely reliable estimate of

the cost of operating a factory, and the probable returns, in Michigan or in the Eastern rainfall district:

COST OF OPERATION OF A 600–TON FACTORY, FOR A 100 DAYS' CAMPAIGN, CUTTING 60,000 TONS OF BEETS.

	Total cost		Per ton of Beets
Beets, 60,000 tons (14 per cent), at $5.16	$309.600		$5.16
Coal, 20 per cent of beets, 12,000 tons, at $2.50	30,000		.50
Limestone, 8 per cent of beets, 4,800 tons, at $1.50	7,200		.12
Coke, 12 per cent of limestone, 536 tons, at $5	2,680		.044
	———	$349,480	
SUPPLIES			
Sulphur, 20,000 lbs., at .02½c	$450		
Filter cloths, 8,000 yards at 17c	1,360		
Oils, 2,000 gallons, at 25c	500		
Chemicals (average of all factories)	2.000		
Miscellaneous	1,000		
	———	5,360	.089
LABOR			
200 men, average $2.25, 100 days	$45.000		
Superintendent	3.600		
Engineer and assistants	2,000		
Agriculturalist	2,400		
Assistants	2,000		
Office help	3.000		
General manager	2,500		
	———	60,500	1.008
PACKING			
44,000 barrels, at 36c	$15,840	15,840	.264
(NOTE—In the West this item would be 132,000 bags at 8c, $10,560.)			
INCIDENTALS			
Interest, $300,000 bonds, at 5 per cent	$15,000		
Insurance	2,000		
Taxes (?)	2,000		
Repairs	10,000		
Dead season help	5,000		
Miscellaneous	10,000		
	———	44,500	.74

The generally accepted average extraction of sugar in factories without a molasses process is 71 per cent. of the sugar content of the beets.

Assuming the Michigan beets to contain an average of 14 per cent. of sugar, the returns in such case would be 71 per cent. of 14 per cent., or 9.94 per cent., equivalent to 198.8 pounds of sugar, say 200 pounds.

RECAPITULATION

	Total	Per ton Beets
Returns, 13,200,000 pounds, sold at 4½ cents	$595,000	$9.90
Expenses, as per list above	475,680	7.925
Anticipated profit	$118,320	$1.975

It must be understood that these figures are based on the cutting of 60,000 tons of beets during the campaign of 100 days.

A reduction of the supply of beets would cause an increase in the proportionate expense of operation.

These figures might be somewhat varied in either direction, according to the varying conditions of quality and quantity of beets and by the varying circumstaces of competition in securing acreage by factories covering closely adjacent territory.

In the irrigated sections of the West, the result is much more satisfactory. The tonnage per acre being nearly or quite 50 per cent. greater, the farmers actually receive more money per acre on a flat price per ton, and by reason of the higher sugar content of the beets, the extraction of sugar is practically 2 per cent. greater and the profit per ton of beets handled is quite $2.50 greater than in the East, which fact will certainly lead to a very large development of the industry in those sections.

Beet Culture

General Directions for Seeding and Cultivating

There is no agricultural product from which the industrious farmer may derive so many advantages as from the sugar beet. Sugar beet raising gives the farmer many times the profit that could be derived from any other crop, while it does not interfere with other crops; but, on the contrary, by improving the condition and capacity of the soil, owing to continued and superior cultivation, produces better grain crops, besides permitting the growing of other high-culture plants and vegetables which could not be grown profitably heretofore.

Method of Growing Beets

It is difficult to lay down general directions and rules for growing sugar beets applicable to all localities and conditions. Often expert sugar beet growers, at public meetings and through the agricultural press, give minute directions covering all the details of this intricate process.

Others, each well versed in the process of growing sugar beets, get into arguments and disputes as to the right method. In such cases each may be correct in a measure. The occasion for such disagreements lies in the fact that each person has in mind the right method for a particular locality or set of conditions. A careful study of the different sections of the United States where sugar beets are grown will lead to the conclusion that there is no single road to success in growing sugar beets. Every locality has settled conditions which will materially modify any set of methods that might apply to some other one. There are some settled rules, of course, but to a great extent the various agricultural districts of this country will have to work out each for itself the right method. The person who argues that the ground must be plowed in the fall, in order to receive the benefit of the winter frost, is not offering any argument to the Pacfic coast, for instance, where many beets are grown. And he who insists that the ground should be rolled in all instances after planting, will hazard the crop if his directions are followed in many parts of Nebraska and other sections where the soil is sandy and there are

strong winds. In such cases a smooth surface offers an excellent opportunity for the wind to carry along the sharp grains of sand, cutting off the plants and destroying the crop.

There can be no general fixed rules regarding the kinds and application of fertilizers. General principles are all right when accompanied by the reasons underlying, but must always be modified to meet local conditions.

With the development of the industry in all sections which have the necessary conditions, and the acquirement of ample experience both by the farmers in the production of beets, and by the manufacturers in the making of sugar, there will come many improvements and eventually a cheapening of production, a result of great importance to all concerned in the success of the industry, because eventually the beet-sugar industry of the United States will have to meet a sharper competition with foreign producers.

There are some things settled, however, about growing sugar beets. It will be generally conceded that the ground should be plowed deep, and in most instances sub-soiled. Before the seed is planted the ground must be thoroughly pulverized by harrowing and by rolling, even if the surface has to be afterwards roughened. Advantage must be taken of the general and prevalent rain conditions. The ground must be moist enough to germinate the seed, either by rainfall or irrigation. In some localities either is used, according to circumstances. Seeds are planted at depths of from one-half to two inches, according to the prevailing conditions in the particular locality. The beets must be planted near enough together to produce a beet of certain size. This spacing depends again upon the locality and the nature and fertility of the soil. The size and quality of the beets depend materially on the right kind of spacing. The beets must be thoroughly cultivated, hoed, and hand weeded, because cultivation tends to conserve the moisture of the soil, and clean fields permit favorable action of sun and air. The sooner the beet is harvested after it is ripe the better, because further rainfall may start a new growth, producing new lateral roots, and new leaves, thus greatly reducing the sugar content and purity of the beets.

Preparing the Seed Bed

Having selected the land, give it a deep plowing in the fall, if possible, and follow by a sub-soiling, and allow it to lay exposed to the action of the elements during the winter.

In the spring, the land should be again plowed about eight inches deep, after which it should be thoroughly pulverized by disking, harrowing and rolling or planking. It is not necessary that all these methods be used at once, but enough of them must be used to accomplish the end in view, which is to thoroughly pulverize the soil.

Special implements are being constantly devised to accomplish this, and all the operations in beet cultivation, harvesting, and topping.

Seed

So far, almost the entire quantity of seed used in this country comes from Europe, that from Germany appearing to be best adapted to our conditions and to produce the best results.

There is some choice to be exercised in this regard. The sugar companies usually furnish their farmers with seed, taking pay in beets.

Not less than 15 pounds of seed to the acre should be used to insure a full, even, and regular stand. Unless the stand be good, there will be many bare spaces, greatly reducing the yield.

A disposition to economize seed or to make the amount furnished cover a larger acreage will be found to be false economy and should not be attempted.

Planting

The seed should be sown with a drill made for the purpose, in rows eighteen inches apart, or of sufficient width to allow of the passage of a horse when cultivating.

When irrigation is practiced, seed is preferably sown in ridges about twenty inches apart to allow for irrigation between the rows so as not to burn the leaves.

The seed should be planted from one-half to one and one-half inches deep, depending upon the moisture in the soil; the shallower the planting, the more vigorous will be the plant. The fear that the

plant may die for lack of moisture is unfounded, as the sprouted seed sends down a long root to the depth of several inches, and later even to two or more feet, from which the beet derives moisture and sustenance.

It should always be borne in mind that the sugar in the beet is derived entirely from the air and sunshine, consequently the tops should have ample space in which to secure all the benefit from these sources. The increase in sugar content will more than make good the decreased tonnage, although growing and breathing space will not necessarily tend to decrease tonnage.

Planting should not be done until the ground becomes warm with a probability of settled weather conditions, say in May in the rainfall districts. In the irrigated districts this must depend upon the general conditions; in some places planting may be done from December to June. In Montana, in May or early June.

Germination

The seed will germinate in about a week after planting if the weather and soil conditions are favorable.

Care should be taken during this period that the ground does not become baked; if this occurs, the farmer should know how to overcome the difficulty with a harrow.

Bunching and Thinning

When the plant has three or four leaves the bunching must be done.

This is done by passing down the row and, with a stroke of the hoe, cutting out a part of the plants the width of the hoe, leaving bunches from 6 to 10 inches apart.

After bunching, or when it is fairly under way, the thinning should be begun.

This, up to this time, has been, and probably always will be, done by hand, laborers crawling along the rows and removing from each bunch all except the most thrifty plants. These plants should be left about six inches apart in good, rich soil, or up to ten or twelve inches in poor or thinner soil.

This is quite the most important operation connected with beet

growing, as its proper performance has a great influence upon yield, both in tonnage and sugar. The vigor of the plant depends upon its being done at the right time, governing the size of the beets, while spacing to the proper distances apart has an important influence upon the sugar percentage.

The aim of the farmer should not be to grow large beets, which run to fibre and are low in sugar, while small beets are more expensive to handle. Beets weighing from one to two pounds are by far the best for the farmer and the factory.

Cultivating

The first cultivation is performed in the bunching and thinning, when the laborer presses the dirt firmly around the beet plant and removes whatever grass or weeds may be present.

After this the weeds should be kept down and the ground kept loose and pulverized, which can be done by hoeing or horse cultivation, using any of the implements made for such purpose. This should be done as often as needed, three times generally being sufficient, or until the plants are large enough to shade the ground, when work among them with plow and horse would break off the leaves.

Irrigation

Where irrigation is practiced the farmer has an opportunity to control the growth of the beet and the development of its sugar to a much greater degree than is possible in the humid sections.

In general, the rules of irrigation as applied to other crops, may be successfully used with sugar beets. It would be well, however, in order to secure a greater downward growth of the beets, to withhold the application of water in each case until the leaves begin to turn yellow. In this way the disproportion of tops to the rest of the root may be reduced and the proportion of sugar correspondingly increased. It is also advisable to avoid very late irrigations.

Harvesting

When one is accustomed to sugar beet fields, it is easy to determine when they are ripe. This point is usually determined, however, by analysis to ascertain the sugar content and purity of the beets.

After the growth of the top and root and cultivation ceases, the beets begin to store up sugar through the leaves, and the sugar and the purity increases as they approach maturity.

When a field of beets is ripe, the leaves tend to droop and the whole field takes on a yellow appearance, which cannot be mistaken by one accustomed to deciding the period of ripeness.

There are several kinds of harvesting plows, beet pullers and toppers, many of which have lately been patented, from which a satisfactory implement may be chosen.

Having been loosened by either of the ordinary machines, laborers follow, throwing the beets in piles.

Topping

This is done by laborers with a sharp knife, made especially for the purpose, striking a quick, sharp blow, cutting off the top square across as low as the lowest leaf stem. The beets are thrown into large piles and the tops plowed under or used for fodder.

The topping is a very particular and important operation.

The sloping crown of the beet bearing the leaf-stems contains much the larger proportion of the mineral salts in the vegetable, which are very objectionable in the manufacture of sugar, every pound of such salts preventing a pound of sugar from crystallizing.

Beets not topped properly are re-topped by the agricultural department of the factory and the difference in percentage of weight, calculated on the samples, is deducted as tare.

In climates where there is no danger of wet or freezing weather, the roots may be left on the ground unharvested for a long time.

Siloing

While beets should be harvested as soon as they are ripe, to avoid the deteriorating effects of frost or rain, yet not all beets can be delivered to the factory at the same time. The beet sheds have not sufficient capacity. Many companies require that a certain portion of the beets shall be siloed in the fields where they are grown. This is accomplished by placing them in single piles containing a good load, or in long ricks.

Plows are run up and down alongside of these ricks or piles, and the soft dirt is thrown over the beets to the depth of several inches. Then hay, straw and beet leaves are thrown on top of that. Holes are left for ventilation. Beets can be kept for some time in this manner.

Freezing of the beets does them no particular injury, and does not appreciably diminish the sugar content, provided they can arrive and be worked at the factory before thawing out.

Thawing after freezing reduces the amount of sugar and the purity, and must be guarded against.

The delivery of beets as well as the specific instructions for growing are regulated by the agricultural department of the various factories, and the whole progress of the work is usually supervised by the skilled members of that department employed by the factory.

It is decidedly to the farmers' interest as well as to that of the factory that such instructions should be graciously received and carefully followed.

It cannot be too strongly impressed upon the minds of farmers that the interests of both farmer and factory are identical and mutual; what benefits the one adding to the success of the other, and no spirit of antagonism or differences should be permitted to arise.

General Data Condensed

The amount of fuel required per ton of beets varies from 15 per per cent. to 21 per cent. The latter was the average of Michigan factories for the campaign of 1901–2. Proper connections, careful attention to details and skillful utilization of heat units and the hot water supply should keep the amount approximately at the lower figure.

The quantity of lime rock used is about 8 per cent. of the weight of the beets when using the ordinary milk of lime for carbonatation. Where the Saccharate of Lime process is used for treating the molasses, the proportion will be from 16 to 20 per cent.

The quantity of Coke is about 10 to 12 per cent. of the weight of the Lime Rock.

The amount of Sulphur used is about 200 pounds per day; other supplies about $50 per day.

The number of men employed, outside the office force, in some of the factories is 170 to 180. In some others, of the same capacity, 250 are required.

The annual disbursement for labor, including office, will be about $60,000.

In raising and harvesting the crop of beets for the Michigan factories for the campaign of 1901-2, there were engaged 26,966 men, 1,844 single horses, and 4,834 double teams employed during the season.

The actual number of contractors raising beets for the same factories for that season was 16,848. This represents the same number of farmer's families and, on a basis of five members to the family, represents 84,240 persons actually interested in the agricultural operations of the Beet Sugar Industry of Michigan in that year. Last year these figures were presumably 25 per cent. greater.

Beet seed is purchased by the factories in the month of Decem-

ber, distributed to the farmers in the month of April and paid for by the farmers from the sale of beets in the fall.

The Beet Sugar Industry is the agricultural industry in which the farmer is able to sell his crop, on a reliable contract, at a fixed price, before the seed is planted.

He is thus independent of the action of the law of supply and demand, or of the many contingencies of the market on other crops at time of harvesting. He is not subjected to delays in payment nor compelled to hold his crop for a better market.

Sugar beets will withstand a longer drought and also a more excessive rainfall than any other known staple crop. The danger of loss from bad weather conditions is thus minimized.

Calculations

In making the various calculations in the Beet Sugar Industry, it will be apparent that they are approximately correct when expressed in decimal proportion; that is, the relation of each to the other is expressed in some multiple of ten.

In the Eastern section the average tonnage per acre is set at 10 tons.

The acreage of beets to be contracted for should be 10 times the daily capacity.

The tonnage of beets worked is practically 10 times the amount of sugar which should be extracted.

The campaign is 100 days.

The approximate cost of the completed plant is about $1,000 for each ton of daily capacity.

These estimates are sufficiently near for all practical purposes.

Refineries vs. Home-Grown Sugar

Eastern refiners buy brown (raw) sugar, produced from cane in the tropics or from beets in Europe. This sugar has had expended upon its production fully 90 per cent. of all the labor and other cost.

The cost of refining is from 30 to 40 cents per 100 pounds, of

which not exceeding 15 cents is for American labor.

This sugar is melted, reboiled and clarified by passing through bone black (animal charcoal) and the refined sugar separated from the molasses precisely as in the Beet Sugar process. In fact, the machinery is identical with that in the sugar end of the beet sugar factories, except for the addition of the char-filters for the necessary clarification.

The present price, April 1, 1903, of raw sugar, 96 degrees Centrifugal, landed in New York, cost and freight, is 2 1-16 cents, and this all goes to the foreign producer.

The American beet farmer receives for one ton of beets containing 14 per cent. of sugar, in Michigan, $5.16. Upon the assumption that the factory is able to extract from this 200 pounds, the farmer receives 2.58 cents per pound for the sugar still in the beets, in the shed, upon which all labor and factory expense must be expended.

The duty on raw sugar polarising 96 degrees is $1.68½ per 100 pounds.

The cost, duty paid, is about 3¾ cents per pound.

The Future

It is estimated that in 1910, the amount of sugar required for consumption in the United States, above that produced from home-grown cane, will be 3,000,000 tons.

Europe, with much less available beet area, produced in 1900, 5,950,000 tons of beet sugar.

To produce 3,000,000 tons of beet sugar annually would require 500 plants, each having a daily capacity of 600 tons.

These plants would represent the following investment and annual business:

Invested in plants	$300,000,000
Working capital	50,000,000
Acres of beets	3,000,000
Valuation of land growing this crop	150,000,000
Tons of beets	27,000,000
Tons of sugar	3,000,000
Value of beets	135,000,000

Annual pay roll for labor in factories	42,000,000
Tons of coal used	5,500,000
Tons of lime rock	1,890,000
Tons coke	208,000
Freight paid railroads	27,000,000
Annual payments, bags and barrels	6,000,000
Number of farmers raising beets	750,000
Men employed in factories	125,000
Men employed raising beets during season	1,200,000

Statistical

Present Sources of World's Sugar Supply

BEET

	1901	1900	1999	1898
Germany	2,270,000	1,979,098	1,798,631	1,721,718
Austria	1,250,000	1,094,013	1,108,007	1,051,290
France	1,200,000	1,170,332	977,850	830,132
Russia	1,050,000	920,000	905,737	776,066
Belgium	350,000	340,000	302,865	244,017
Holland	190,000	178,081	171,029	140,763
Other European Countries	400,000	387,440	253,929	209,115
Total foreign	6,710,000	6,068,994	5,518,048	4,982,101
United States	150,000	76,859	72,944	32,471
Total beet	6,860,000	6,145,853	5,590,990	5,590.572
CANE				
Cuba	875,000	635,856	308,540	345,260
Java	765.000	710,120	721.993	689,281
Brazil	215,000	190,000	192,700	154.495
Mauritius	145,000	175,267	157,025	186,487
Australia	117,000	111.554	123,289	192,247
Argentine Republic	115,000	114,252	91,507	72,000
Peru	105,000	105,000	100,381	61,910
Other Foreign Countries	753,000	731,880	681,219	748,926
Total Foreign Cane	3,090,000	2,773,929	2,376,654	2,450,606
UNITED STATES:				
Louisiana	290,000	275,000	132,000	245,511
Porto Rico	100,000	80,000	35,000	53,826
Hawaiian Islands	300,000	321,461	258,520	252,507
Philippine Islands	70,000	52,000	62,875	93,000
Total, U. S. and possessions	760,000	728,461	488,305	644,844
Total cane	3,850,000	3,502,390	2,864,959	3.095,450
Total Cane and Beet	10,710,000	9,648.243	8,455,951	8,110.022

To illustrate the comparative growth of the beet sugar industry in the United States and Europe, the following table will be interesting:

Beet Sugar Production

	United States. (Tons.)	Europe. (Tons.)		United States. (Tons.)	Europe. (Tons.)
1870	400	899,600	1892	12,018	3,442,198
1872	500	1,018,500	1893	19,550	3,889,845
1878	200	1,418,800	1894	20,092	4,790,532
1880	500	1,747,500	1895	29,220	4,285,429
1883	535	2,146,470	1896	37,536	4,916,498
1884	953	2,574,047	1897	40,399	4,831,774
1886	800	2,732,200	1898	32,471	4,982,101
1888	1,010	2,724,000	1899	72,944	5,518,048
1890	2,800	3,707,200	1900	76,859	6,068,994
1891	5,359	3,501,920	1901	150,000	6,710,000

Detailed Supply of the United States, 1901

DOMESTIC

Cane	292,150 tons.	12.4 per cent.
Beet	124,859 tons.	5.2 per cent.
Molasses Sugar	17,977 tons.	.7 per cent.
Maple	5,000 tons.	.2 per cent.
	439,986 tons.	18.5 per cent.

FROM INSULAR POSSESSIONS, CANE

Hawaii	309,070 tons.	13.2 per cent.
Porto Rico	64,052 tons.	2.7 per cent.
Philippine Islands	5,100 tons.	.2 per cent.
Total from Insular possessions	380,449 tons.	16.1 per cent.
Total, Domestic and Insular possessions	820,435 tons.	34.6 per cent.

FOREIGN

Cane	1,292,080 tons.	54.6 per cent.
Beet	217,286 tons.	9.6 per cent.
Refined	42,515 tons.	1.7 per cent.
Total Foreign	1,551,881 tons.	65.4 per cent.
Grand Total	2,372,316 tons.	100.0 per cent.

Average Increase in Total Consumption Per Year for Twenty Years

France	6.18 per cent.
Germany	6.91 per cent.
Austria	4.65 per cent.
England	3.50 per cent.
United States	6.94 per cent.

Sugar Consumption, Dominion of Canada, 1900, With Sources of Supply

	United Kingdom and British possessions, Tons.	Imported from United States Possessions and Dependencies, Tons.	Other Cane Tons.	Other Beet Tons.	Total Tons.
Raw	11,020	2,689	3	112,613	126,325
Refined	1,238	12,265	1,684	1,247	16,434
	12,258	14,954	1,687	113,860	142,795

It will be seen that more than 75 per cent. of the total supply in Canada was from sugar beets.

The customs duties in Canada are 71½ cents per 100 pounds on raw sugar, (96 degrees, Centrifugal) and $1.20 on refined sugar, against $1.68½ and $1.95 respectively in the United States. This duty should be materially increased before the production of beet sugar can attain any considerable development.

Having had an opportunity during the last few months to become acquainted with the conditions in Colorado, I will give some data showing what the establishment of a factory means to a community.

Loveland, Colo.

The Loveland factory is said to employ 400 men and boys during the sugar making season, the payroll being about $25,000 per month, or for the 120 days, or four months, of the factory campaign, about $100,000.

About 35 of the skilled factory employes, the office force, the agricultural superintendent and his corps of assistants, are employed the year round, representing a payroll for the eight months during which the factory is idle, of about $4,000 per month, or about $32,000, making the annual pay roll about $132,000.

The local beet growing industry, following the erection of the Loveland factory, has resulted in the immigration into the district of about 1,500 laborers, old and young, who came to Colorado from Nebraska,

The wages paid in the beet fields for ordinary common labor, doing hand-work, range from $1.50 to $2.50 per day, if reckoned that way, but the field laborers generally contract to do the necessary hand-work,

viz., the thinning and hoeing, second and third hoeings, pulling and topping, for $20 per acre; father, mother and children working on the family contract.

Around Loveland beets are regarded as not merely a more profitable crop than wheat or other grain, or alfalfa, or potatoes, but as a safer crop, as much less liable to serious damage from hailstones.

The beet pulp produced by this factory is sold to local stock feeders at 35 cents per ton, being mainly used for sheep.

It has necessarily given quite an impetus to local stock feeding.

The beet tops, left in the fields after the beets are harvested, are valuable either as feed for cattle and sheep, or as a fertilizer when ploughed under.

It is difficult to overestimate the benefit of this factory to the Loveland district. It has already materially enhanced the market value of all farm lands within its sphere of influence; promoted diversified farming; rotation of crops and more intensive agriculture. The $1,472,000 paid to local growers for beets during the three seasons the factory has been in operation, has necessarily gone into general circulation and benefitted not merely the Loveland district in particular, but Colorado in general, in a variety of ways, insomuch that the continued success of the enterprise is, or should be, a matter of interest to every citizen of Colorado.

Sugar City, Colo.

The beet sugar factory of the National Sugar Manufacturing company at Sugar City presents somewhat different circumstances to the other beet sugar factories in Colorado.

Sugar City is situated fifty-six miles east of Pueblo on the line of the Missouri Pacific railway, or about 160 miles by railroad from Denver.

In the spring of 1899 the site of the present Sugar City was merely "an expanse of plain and sky," a "round-up" point for the open range cattle industry, and tenanted by prairie dogs and occasional coyotes. Sugar City was incorporated in June, 1900, and to-day has a population of about 1,500, with hotels, business houses, a bank, a fire

department, a $10,000 school house and a $20,000 water works plant' the bonds of which were sold at par.

All this has followed the erection in 1899 of a beet sugar factory at Sugar City by the National Sugar Manufacturing company.

It naturally took some little time to get the beet growing industry started. The first year the factory was erected remarkable progress was made, considering the difficulties which had to be overcome. The industry was entirely new to that section. The farmers were unfamiliar with the method of raising the beets, laborers had to be brought from distant places and were compelled to live in tents for the greater part of that year, and the land was but a vast area of new and unbroken prairie. Nevertheless, 12,000 tons of beets were raised the first year·

A Large Territory

The area tributary to the factory extends along the line of the Missouri Pacific railroad, practically as far as Pueblo, taking in the flourishing agricultural communities of Ordway, Olney, Fowler, Baxter, Vineland, etc., and representing at least 50,000 acres of irrigable land. The main crops of this tributary area, until the advent of the factory, were alfalfa, grain, etc. There is not much live stock, except on the open ranges north and south. There is little dairying or poultry raising, but there are numerous orchards, and honey is shipped out by the carload. In the vicinity of Ordway, about six miles west of Sugar City and the factory, the farms are of good size, the farmhouses and outbuildings substantial and well painted. The farmsteadings are invariably surrounded by orchards, shade trees, hay and grain ricks, and usually also have a cluster of white tents, occupied by the laborers for the beet fields.

The National Sugar Manufacturing company owns 12,000 acres of land surrounding Sugar City and the factory, the Missouri Pacific railway passing diagonally through the center of the tract. This body of land, which lies in compact form, is an excellent alluvial deposit of light loam, mixed with fine gravel, yielding readily to the plow and easy of cultivation.

Just north of this area runs the Colorado canal, owned by the Twin Lakes Land and Reservoir company, from which the whole of the 12,000 acres of the National Sugar Manufacturing company is irri-

gable. The Meredith lakes south of the town, have a circumference of thirteen miles, the volume of water in which, though varying with the seasons, never fails.

The Water Supply

The National Sugar Manufacturing company owns extensive water rights, Lake Henry, fed by means of a priority right from the Arkansas river through the Colorado canal being the base of supply. In other words, from Twin Lakes, 2,000 acres in extent, with average depth of eighty-five feet, in Lake county, at an altitude of 9,200 feet, the water is carried in a natural canal to the Arkansas river, a distance of nine miles. Then down the Arkansas river for a distance of 150 miles to Boone, east of Pueblo, at Boone taken into the Colorado canal and conveyed a distance of thirty-five miles to Lake Henry and from there, through a wooden stave pipe to Sugar City and the adjoining land of the National Sugar Manufacturing company. When the Arkansas river supply becomes short, as it usually does during the middle of the summer, the headgate at Twin Lakes is opened and the necessary amount of water liberated, which in about two days, via the Arkansas river, the Colorado canal and Lake Henry, is delivered for irrigation use around Sugar City.

In addition to this, the great storage reservoir of Lake Henry, four miles northwest of Sugar City, holds a vast volume of water ready for any emergency of threatened drought.

It is said that the before-mentioned facilities preclude shortage of water around Sugar City.

Land Under Cultivation

The company is cultivating a considerable portion of its 12,000 acres of land, 4,000 acres being devoted to beets. A quantity of the company's land is leased to other beet growers and the remainder is grown by the company to alfalfa and grain crops as a precursor to beets.

The total cost to the company of handling its portion of the 12,000 acres this season will be about $250,000, by far the greater part of the expense being on the 4,000 acres of beets.

In addition, about 140 beet growers, owning or leasing land along

the line of the Missouri Pacific railroad, with an average of eleven acres of beets each, have contracted to furnish the factory this season with the beets from about 1,500 acres.

Taking the average yield per acre at the low estimate of ten tons, the factory should slice from all sources between 40,000 and 50,000 tons of beets this season.

For beets which contain 14 per cent. sugar, the company pays $4 ton, allowing 25 cents extra per ton for each 1 per cent. of sugar. The average sugar contents are 17½ per cent. and in some exceptional cases the beets test as high as 21 and 22 per cent. The average price the growers receive is about $4.87 per ton. Many of the beet growers raise an average of twelve tons to the acre, while some raise as high as fifteen and twenty tons per acre.

Some Statistics

One grower near Ordway received from the company for beets delivered from two and three-quarters acres, $365.39 or $132.84 per acre. He did a large part of the work himself, but assuming that the value of his own labor and whatever other labor he had to pay for was $32 per acre, it still left a profit of $100 per acre.

Another company received from the company about $2,500 for the beets from forty acres.

Another grower, who leased forty acres of the company's land, raised an average of sixteen tons per acre of high quality and received from the factory therefor about $3,000.

The cost of production of an acre of beets at Sugar City is conservatively stated as follows:

Plowing	$3.50
Irrigating, winter (once)	.75
Irrigating, summer, (three times)	1.00
Harrowing, (three times)	.90
Seed	3.00
Seeding	.50
Cultivating (5 times)	2.00
Bunching and thinning, by contract labor	6.00
Hoeing, by contract labor	6.00

Pulling and topping, by contract labor	6.00
Plowing up beets	2.00
Hauling (ten tons)	5.00
Per acre	$36.65

It is said that the above figures can be somewhat reduced by less cultivating and by the grower doing his bunching and thinning, hoeing, pulling and topping by the month. Even on the above showing, a production of fifteen tons per acre means over $73 per acre, or a net profit of nearly $30 per acre, while at ten tons per acre there is still a fair profit to the grower

Heavy Pay Roll

In addition to the amount paid this season by the factory to independent growers for beets, the company has an annual payroll of between $150.000 and $200.000, covering the 190 factory employes during the sugar making season of about 120 days, commencing October 1, the maintenance of the administration crops, about forty in number, during the other eight months of the year, and the force required to run that part of the company's 12,000 acres of land, not in beets, operated by the company. Further large sums are expended in Colorado in the purchase of coal, lime rock, etc., and in railroad freight.

The factory treats 500 tons of beets per day during the season and produces 120,000 pounds or sixty tons per day of pure white granulated sugar therefrom.

Its modus operandi of manufacturing resembles that at other Colorado factories sufficiently to call for no repeated description here. As it stands to-day, the factory has cost approximately $500,000.

During the agricultural season the company employs about 1,000 persons old and young. on the acreage of beets grown by itself, while the independent growers employ outside help to the number of at least 500 persons.

The usual price for hand work is about $18 per acre; man and two horse team get $3 per day, and irrigators $1.75 per day. One beet worker received one check for $900 for his personal contract labor from May 1 to November 1. Many others received amounts equal to this for similar contracts.

Foreign Labor

The bulk of this labor is performed by people commonly known as Russians, but really people of German race and language born in Russia. It is said that these German laborers around Sugar City, while coming here from Nebraska, came originally from the provinces of Saratov and Samara in the valley of the Volga and are descendants of German emigrants who settled in that part of Russia in the middle of the Eighteenth century. They are said to speak the German which prevailed over a century ago, like the Canadians of Lower Canada largely speak the French which prevailed in France at the time when their ancestors emigrated from France to Lower Canada. These German-Russian laborers have built a Lutheran church and have their own resident pastor. They are phenomenally industrious, father, mother, and children working in the fields side by side early and late. A number of the men who came first have purchased, with their savings, serviceable teams and wagons and do most of the beet team work at so much per ton. Some of the older comers have ceased to dwell in tents, having acquired small tracts of land and erected their own houses.

Many Phases

There are also about 100 Mexicans, chiefly engaged in loading or unloading beets rather than field work, but they are transients, only staying around Sugar City for the sugar making season.

The residum pulp from the factory has given an impetus to the local feeding of cattle and sheep, one packing company of Pueblo feeding 3,000 head of steers and 500 sheep at Sugar City this season.

The National Sugar Manufactory company has reclaimed and put into profitable production a large tract of Colorado land.

It has annually, for five consecutive years, disbursed large sums of money in the employment of profitable labor in Colorado and for beets produced by independent growers. It has added another prosperous community to the state. It obviously merits full appreciation and support from the citizens of the state, no matter where resident of the state.

The Greeley District.

The Greeley district was the pioneer in Colorado of agriculture on

any considerable scale, by means of irrigation, and its success in the '70s gave the impetus which resulted in similar enterprises and reclamation of dry land at many other points in the state. Had the Greeley colonists been less indomitable in the early '70s and allowed themselves to fail in their efforts, the development of agriculture, as it exists in Colorado to-day, might have been postponed possibly twenty years. The whole state, therefore, is infinitely indebted to the Greeley colony for its pioneer work of converting semi-arid lands into fertile fields by artificial irrigation from the streams fed from the melting snows and eternal springs in the mountains.

Of the seventy-five square miles of irrigated, cultivated land sur. rounding Greeley the respective acreages of various crops for the season of 1903 are estimated in the following order: (1) alfalfa, (2) potatoes, (3) wheat, (4) sugar beets, (5) oats, (6) barley.

That portion of the land which has been in continuous cultivation since the early '70s is more productive now than ever before for various reasons, viz: (1) more intelligent and economic use of water, (2) more thorough cultivation, (3) the utilization of alfalfa, plowed under as a fertilizer, (4) rotation of crops, (5) increased use of barnyard and sheep pen manure, (6) improvement in agricultural implements and appliances and in grade of farm horses.

High Wheat Average.

Years ago the average local wheat crop ranged from twenty-five to thirty bushels per acre, while to-day, it is said to range from thirty to as high as sixty bushels per acre, the minimum average being forty bushels.

Potatoes formerly used to range from seventy to eighty sacks (of 100 pounds each) to the acre, while for the season of 1903 they are said to average at least 100 sacks per acre.

With the increased average yield of wheat and potatoes, the cost of production per bushel and per sack has decreased.

The estimated cost of raising wheat around Greeley is said to be about $10 per acre. An average yield of forty bushels per acre, at present price of 90 cents per bushel, means $36 per acre, or a profit to the grower of, say, $25 per acre.

The estimated cost of raising potatoes around Greeley is said to be from $30 to $35 per acre, including seed. An average yield of 100 sacks per acre, at present price of 70 cents per sack, means $70 per acre, or a profit to the grower of, say, $35 per acre.

It is estimated that Weld county this season has raised and will ship 8,000 cars of potatoes, averaging at least fifteen tons per car, of which at least 4,000 cars, or 60,000 tons, were raised in the ten square miles immediately surrounding Greeley, where the "dugout" for potato storage is an adjunct on practically every farm.

These Greeley potatoes, on account of their superior quality, have been for years shipped throughout the Southern and Middle states, and even as far east as New York and Boston, 2,000 miles by railroad.

Beet Sugar Factory

In 1902 the Greeley Sugar company built and completed a beet sugar factory at Greeley with a daily capacity of 600 tons of beets.

The officers of the company are: C. S. Morey, president; C. A. Granger, vice president; M. D. Thatcher, treasurer, and W. A. Dixon. secretary.

The factory as it stands to-day, including first cost and subsequent additions and improvements, represent a cash investment of $750,000. The factory premises cover sixty-five acres, and the site is ideal.

While there is a sufficient resemblance between the various factories of the state to render unnecessary a special description of the Greeley factory, it may be said of this factory, that it was evidently designed and built by experienced men with a view to maximum efficiency at minimum first cost and subsequent cost of operation. The factory has a well, through the gravel down to bed rock, from which 1,000,000 gallons per day of pure water is pumped and used exclusively in the manufacture of sugar.

Wide Territory Covered.

In 1902, its first season, the factory sliced 40,000 tons of beets, paying the farmers $180,000 and making 8,000,000 pounds of sugar.

For the season of 1903 it is estimated that the factory will slice 55,000 tons of beets, paying the growers therefore $247,000 and making therefrom 12,000,000 pounds of sugar.

In the season of 1903, 4,800 acres of beets were contracted for the factory, the territory being far reaching at points along the Union Pacific railroad, on the Denver line as far as Fort Lupton, twenty-six miles from Greeley, and along the Julesburg line as far as Deuel, forty miles from Greeley. The factory has four dumping stations on the line of the Union Pacific, viz., at Goodrich, Kersey, LaSalle and Fort Lupton. About three-fifths of the factory's supply of beets this season came in by railroad from various points along the Union Pacific and the remaining two-fifths were delivered by wagon from growers within a radius of about five miles from the factory.

There were 550 individual growers who averaged about nine acres each, the average yield being about twelve tons per acre. One man with twenty-two acres raised twenty-six tons per acre. Other growers with smaller tracts raised as high as thirty and even thirty-two tons per acre, showing what can be done.

Cost of Production

The cost of production of the beets is said to range from $30 to $40 per acre, depending on what the grower has to hire. It is said that a man can rent land, pay for water, hire a foreman and pay for all necessary work and still raise beets at a total cost of not to exceed $40 per acre.

In 1902 the payroll of the factory during the sugar making season, commencing October 10 and finishing January 17, is expected to be about $70,000, and during the fiscal year $19,000.

The beet pulp from this factory amounting to over 20,000 tons this season, is giving an impetus to local stock feeding, mostly sheep. Ninety per cent. of the pulp will be fed to stock within a mile and a half of the factory, and two cars of pulp per day are being shipped to points along the Union Pacific, as far as Fort Lupton on the Denver line, and as far as Masters and Orchard on the Julesburg line.

The price of the beet pulp is 35 cents per ton f. o. b., also 35 cents per ton at the silo for local beet growers, and 50 cents at the silo to non-beet growers. According to the United States government report beet pulp is worth $1.22 per ton for stock feeding purposes.

Sheep Industry.

Near the factory the company has 5,000 Mexican and Southern sheep, including many old ewes, being fattened on pulp and hay. They were delivered in the factory pens on October 28 and it was estimated there were 1,000 head ready for market.

It is estimated there will be a net profit of at least $1 per head on these 5,000 sheep, besides 1,000 loads af manure, which is sought after by farmers at 75 cents per load. These pulp fattened sheep are shipped to Missouri river points as far as Chicago.

The Greeley beet sugar factory represents a cash investment of $750,000, and in its two seasons' operations has practically already paid $427,000 for beets and $168,000 in payrolls, or a total local disbursement in two years of nearly $600,000, to say nothing of cost of coal, lime rock, railroad freight, taxes, etc.

Eaton, Colo.

Eaton has a population of about 1,000, and has two banks, two hotels, two school houses, costing $30,000, a newspaper, a gas plant, water works system, sewerage system, telephone system, three churches, elevator with a capacity of 110,000 bushels, flouring mill of 400-barrel daily capacity, and a beet sugar factory of 600 tons daily capacity. There are no saloons.

The agricultural country tributary to Eaton is about 100 square miles in extent, and contains several thousand population. In it there are about 150 miles of main irrigating canals, mostly fed from the Cache la Poudre, but some from the Larimer river.

A Great Farming Country.

Taking the average 160-acre farm, the various crops are generally represented about as follows: alfalfa, forty acres; potatoes, forty acres; sugar beets fifteen acres; grain, wheat predominating, sixty-five acres. There are comparatively few eighty-acre farms, larger sizes prevailing.

A special feature of the district is large ownerships and the renting the land to tenants on shares. For instance, ex-Govenor B. H. Eaton owns 15,000 acres of which 12,000 acres are under cultivation,

while his two sons aggregate an additional 6,000 acres, not one of the three doing any farming himself, but renting his land out to the actual cultivators on shares. The owner furnishes the land, irrigating water, house and other improvements, receiving as rent one-third of the grain and potatoes, one-fourth of the sugar beets, one-half of the alfalfa. The tenant furnishes the implements, working animals and the labor, taking the remainder of each crop as his share. This gives the tenants a chance, which many of them would not otherwise have. A limited capital will purchase seed and horses, and hire machinery, with the certainty of getting two-thirds of the grain and potatoes, three-fourths of the sugar beets. and one-half of the alfalfa raised, while in the event of a bad year or poor crop the tenant farmer is not expected to find a certain amount of cash for a fixed rent, whether he has made it or not. In fact, it is a partnership which works well for both land owner and tenant, is equitable and has enabled many a man to make a start which he could not have done in any other way.

The Eaton Sugar Company.

The Eaton district during the past season raised about 150,000 bushels of wheat and about 1,500 cars, or 22,500 tons, of potatoes, netting the growers, at $210 per car, $315,000.

In 1802, the Eaton Sugar company built and completed a beet sugar factory at Eaton, with a daily capacity of 600 tons of beets.

The officers of the company are: C. S. Morey, president; W. D. Hoover, vice-president; M. D. Thacher, treasurer, and W. A. Dixon, secretary.

The factory as it stands to-day, including first cost and subsequent additions and improvements, represents a cash investment of $750,000.

The factory premises comprise sixty acres and the site is advantageous. In general matters it sufficiently resembles the other factories in Colorado as not to call for any detailed description here.

In 1902, its first season, the factory sliced 35,000 tons of beets, paying the farmers therefor at the rate of $5 per ton, $175,000.

For the season of 1903 it is estimated the factory will slice 60,000 tons of beets, paying the farmers therefor, at the rate of $5 per ton, $300,000.

Hundreds of Growers

In the season of 1903 there were about 6,000 acres of beets contracted for the factory, mostly grown within a radius of eight or ten miles from the factory, the company having two dumping stations on the Union Pacific railroad, north of Greeley, viz., one at Lucerne, and the other at Ault. This factory has also received beets from the districts south of Greeley. About 65 per cent. of the beets come by wagon from the farms within three to four miles, and the other 35 per cent. come railroad.

There were about 400 individual growers last year, who averaged about fourteen acres each, the average yield being upwards of twelve tons per acre. There were instances where growers raised as much as thirty-six tons per acre, and in some cases of small tracts, receiving special attention, even as high as forty tons per acre.

The local cost of beet production ranges from $30 to $35 per acre.

In 1902 the payroll of the factory during the four months' sugar making season was about $40,000, and during the eight months while the factory was idle, about $25,000.

In 1903, the payroll of the factory during the sugar making season, commencing October 1 and finishing January 10, is expected to be $50,000, and during the remainder of the fiscal year $25,000.

Fortunes Paid Out

The beet pulp residue from this factory, amounting to about 30,000 tons this season, is sold at 30 cents per ton at the silo, and is being used, along with hay, etc., for the feeding of 30,000 sheep within modarate radius of the factory. At the time of the writer's visit, December 21, there were said to be about 12,000 sheep in feeding pens adjoining the factory.

Having regard to the fact that the Eaton beet sugar factory represents a cash investment of $750,000, and in its two seasons' operations has practically already paid $475,000 for beets and $140,000 in payrolls, or a total local disbursement in two years of about $615,000, to say nothing of cost of coal, lime rock, railroad freight, taxes, etc., the writer was unprepared for the statement from a prominent Eaton man man that there was considerable local prejudice against the beet grow-

ing, as beets are supposed to impoverish the soil. It is surprising how people, who could be expected to know better, jump to unwarranted conclusions, without first making some careful investigation. Yet here is a local example of beets as compared with potatoes and showing that beets improve the soil for other crops.

Some Good Returns

Mr. William Stanley of Lucerne, grew for the Eaton sugar factory in 1903, on rented ground, belonging to a Greeley merchant, twenty acres of beets, which yielded 483 tons, for which he was paid by the factory $2,415.

After deducting $200 paid for bunching, thinning, and hoeing, $241.50 for pulling and topping, and $805 (the value of the land owner's share of the crop) for rent, he had left a net balance of $1,168.50, or $58.42 net per acre.

During the same season, 1903, he grew on the same farm thirty acres of potatoes, yielding 2,950 sacks, which he says will shrink in weight by the time they are sold to 290,000 pounds. If sold at present price of 80 cents per 100 pounds, they will realize $2,320. From that amount he deducts picking, $147.50; sacks, $60; twine, $3; taking out of "dug-out," $58; or a total of $268.50, which, added to $1,160 (the value of the land owner's share of the crop) for rent, makes his expenses $1,428.50, leaving him $891.50 net for the thirty acres of potatoes, or $29.71 net per acre, as compared with $58.42 per acre for his beets.

How One Man Was Paid

In the above comparison there is no mention of the cost of irrigating, cultivating, digging, etc., as Mr. Stanley says those items are about the same in beets as in potatoes, but if anything rather in favor of the beets; as beets can be dug with two horses, while four are required for digging potatoes.

In 1902 Mr. Stanley had a certain thirty acres of which five acres were in beets, yielding twenty tons per acre, and the other twenty-five acres being in wheat, which, however, was destroyed by hail June 27, did not yield an ounce of wheat, though irrigated, and therefore remained practically fallow in 1902. Of this same thirty acres, in 1903 he planted the five acres in potatoes which had been in beets in 1902,

and they yielded 655 sacks, or 131 sacks per acre. The other twenty-five acres which had been in wheat in 1902 he also planted with potatoes in 1903, and they yielded 2,295, sacks, or an average of 91.8 sacks per acre, as compared with 131 sacks per acre on the five acres which had previously grown beets. Mr. Stanley's experience is by no means an isolated case.

Industry Yet New

The sugar beet industry in Colorado is too new for Colorado people yet to know all about it, and Colorado can learn much from Germany, where the industry has been long established and has been largely brought down to scientific principles.

Report No. 74 (page 149) of the United States Department of Agriculture says that the influence of beet culture on the farmer's land is best shown by reproducing that portion of the report of one of the United States consuls in Germany. which treats of the effects of beet culture in rotation with other crops. The Germans are not only exceedingly systematic, but very scientific, and the following report of exhaustive experiments most carefully made, should serve to undeceive any who erroneously believe that sugar beets rapidly exhaust the soil.

The United States Consul's report is as follows;

Some German Figures

"A German farm of 625 acres produced, before the introduction of beet culture, yearly 9,736 bushels of grain in ten years' average. After beet culture was introduced, with 125 acres yearly to beets, the average yearly grain crop from the remaining 500 acres was 9,870 bushels, or 134 bushels' increase. Another farm in the province of Saxony, also of 625 acres, produced, before beet culture was introduced, in ten years' average, 13,879 bushels of grain. When five years afterwards 135 acres were planted with beets, the grain crop of the remaining 490 acres was 14,365 bushels' average, and afterwards, when yearly 220 acres of beets were planted, the average grain crop from the remaining 405 acres was 14,397 bushels, or 518 bushels more than from the whole 625 acres before beets were raised."

The figures of thirty-five other farms of from 500 to 1,000 acres each, in the province of Saxony, are given on page 150 of Report No.

74, the average beet crop on which was 17 1-5 tons per acre, and showing that, in consequence of growing sugar beets in rotation with other crops, the average yield of the other crops was increased as follows: Wheat, 24 per cent.; rye, 14.8 per cent.; barley, 25.2 per cent.; oats, 41.5 per cent.; peas, 86 per cent.; potatoes, 103.2 per cent.

Should Study Subject

In the light of the experience of Germany, it is evident that the farmers in Montana, who desire to materially increase the average of their crops of wheat, oats, potatoes, etc., cannot do better than grow sugar beets in rotation with such other crops.

On this subject, Report No. 74 of the United States Department of Agriculture says that the above quoted German demonstration "shows that the farmer who rotates his beets with other crops does not decrease the productiveness of his land, when sown to other crops, but, on the contrary, greatly increases its productiveness. The truth is that a good farmer cannot measure his profits by his beet crop alone, but must consider the extra profit which beet culture enables him to make on everything else he grows."

The individual beet growers of Montana would do well to study the valuable information contained in the before mentioned Report No. 74, as they would thereby avoid being misled by the prejudiced statements of practically irresponsible persons, who have evidently given insufficient study to the subject.

Report of Crop of 1903.

TABLE OF COMPOSITION, YIELD AND VALUE

Laboratory No.	Co-operating Farmer	Locality	Date Analyzed
2499	H. O. C. Andrews	McLeod, Sweet Grass Co	Sept. 21
2500	I. D. O'Donnell	Billings, Yellowstone Co	" 21
2501	H. Shrammeck	Cascade, Cascade Co	" 22
2502	C. H. Norton	Bridger, Carbon Co	" 22
2503	J. R. Stevens	" " "	" 22
2504	G. F. Hunter	" " "	" 23
2505	J. R. Stevens	" " "	" 23
2506	A. Anderson	Feeley, Silver Bow Co	" 23
2507	C. R. Schurch	Deer Lodge, Powell Co	" 26
2508	M. Flannigan	Billings, Yellowstone Co	" 26
2515	Chas. E. Coleman	Missoula, Missoula Co	" 28
2516	Daniel Payne	Monarch, Cascade Co	" 30
2517	H. Buckhouse	Missoula, Missoula Co	" 30
2518	Jas. Largent	Ulm, Cascade Co	" 30
2525	H. O. C. Andrews	McLeod, Sweet Grass Co	Oct. 3
2532	Theodore Koenig	Kalispell, Flathead Co	" 14
2539	N. D. Root	Whitehall, Jefferson Co	" 14
2547	J. A. Conrey	Cascade, Cascade Co	" 24
2550	H. Shrammeck	" " "	" 24
2551	J. B. Taylor	" " "	" 28
2552	Toman Bros	" " "	" 28
2553	J. R. Stevens	Bridger, Carbon Co	" 29
2554	C. R. Schurch	Deer Lodge, Powell Co	" 29
2555	J. R. Stevens	Bridger, Carbon Co	" 29
2562	P. W. Bradford	Great Falls, Cascade Co	" 31
2563	A. Anderson	Feeley, Silver Bow Co	Nov. 1
2564	Jos. L. Sargent	Ulm, Cascade Co	" 3

TABLE OF COMPOSITION, YIELD AND VALUE.—Continued

Laboratory No.	Average weight	Per cent. sugar in juice	Per cent. sugar in beet	Per cent. total solids in juice	Yield, tons per acre	Per cent. purity
2499	1 lb. 8 oz	16.8	16.0	20		84
2500	4 lbs	10.6	10.1	15.5	20	68.8
2501	1 lb. 8¼ oz	9.1	8.6	14.5		62.7
2502	1 lb. 2 oz	13.2	12.5	17.6		75
2503	1 lb. 5 oz	8.6	8 2	13.7	10	62
2504	1 lb. 5 oz	10.6	10.1	15.5	10	68.3
2505	1 lb. 0 oz	9.0	8.55	13.2	10	68.2
2506	1 lb. 5.5 oz	12.9	12.3	16.9	20	76.3
2507	1 lb. 2.7 oz	14.0	13.3	18.8	10	74.4
2508	1 lb. 8 oz	10.9	10.4	15.5		70.3
2515	1 lb. 13.2 oz	15.6	14.8	18.0		86.6
2516	1 lb. 1.22 oz	15.4	14.6	19.4		79.3
2517	0 lb. 6 oz	11.8	11.2	14.5	4	81.3
2518	0 lb. 14.7 oz	11.3	10.6	15.4		73.3
2525	1 lb. 15 oz	14.4	13.7	16.8		85.7
2532	1 lb. 5 oz	17.8	16.9	22.1		80.9
2539	2 lbs. 5 oz	11.9	11.3	15.4	9	83.8
2547	3 lbs. 0 oz	10.8	10.3	16.0		67.5
2450	2 lbs. 0.7 oz	13.0	12.4	17.8		73
2551	1 lb. 3.7 oz	13.8	13.1	18.7	12 2	73.7
2552	0 lb. 11 oz	14.9	14.2	19.3	7	77.2
2553	1 lb. 5.5 oz	13.2	12.5	18.1	10	72.9
2554	1 lb. 4.7 oz	14.6	13.9	18.8	13	72.3
2555	1 lb. 6.7 oz	14.0	13.3	19.3	10	72.5
2562	1 lb. 9.7 oz	13.0	12.4	15.7	21	82.8
2563	1 lb. 9 oz	13.5	12.8	17.6	20	76.7
2564	1 lb. 0 oz	12.2	11.6	16.6		73.5
Average	1 lb. 8.5 oz	12.5	11.87	17	12.5	74.2

TABLE OF CULTURE NOTES

Laboratory No.	Co-operating farmer	Soil	Date planted	Date thinned
2499	H. O. C. Andrews	Black loam	May 14	June 12
2500	I. D. O'Donnell		" 15	" 10
2501	H. Schrammeck	River bottom	" 20	" 20
2502	C. H. Norton		" 10	
2503	J. R. Stevens	Clay loam	" 24	June 20
2504	G. F. Hunter	" "	" 20	July 1
2505	J. R. Stevens	" "	" 24	June 20
2506	A. Anderson	Sandy loam	" 28	" 20
2507	C. R. Schurch		" 14	July 8
2508	M. Flannigan	Alkali soil		
2515	C. E. Coleman	Sandy loam	May 10	June 25
2516	D. Payne	Bench land	" 13	July 3
2517	H. Buckhouse	Gravelly black loam	" 25	June 10
2525	H. O. C. Andrews	Black loam	" 16	" 14
2532	T. Koenig		" 18	Not thinned
2539	M. D. Root	Gravelly loam	" 15	June 15
2547	J. A. Conrey	Black sandy loam	June 14	
2550	H. Schrammeck	River bottom	May 20	June 20
2551	J. B. Taylor	Heavy black, some alkali	June 6	July 10
2552	Toman Bros	Black sandy loam	May 29	June 15
2553	J. R. Stevens	Clay loam	" 24	" 20
2554	C. R. Schurch	Black loam	" 14	July 8
2555	J. R. Stevens	Clay loam	" 24	June 20
2562	P. W. Bradford	Light sandy loam	" 1	" 15
2563	A. Anderson	Sandy loam	" 28	" 20

TABLE OF CULTURE NOTES.—Continued

Laboratory No.	Date harvested	Width between rows	Irrigation	Cultivation	Remarks
2499	Sept. 18	18 in.	June 20, July 25..	Plowed 8 in. deep.	Season unfavorable
2500	" 18	24 "	" 7 " 7..	" 12 " " .	" "
2501	" 21	24 "	None............	" 6 " " .	" favorable
2502	" 21	......	July 1, Aug. 1	None............	" "
2503	" 21	16 in.	June 10, Aug. 12, Sept. 8.........	Plowed 10 in. deep	" unfavorable, stand poor
2504	" 26	18 "	June 12, Aug. 15, Sept. 1.........	" 10 " "	Season unfavorable
2505	" 21	16 "	June 10, Aug. 12, Sept. 8.........	" 10 " "	" "
2506	" 22	18 "	June 21, July 5, July 20, Aug. 12	" 7 " "	" favorable
2507	" 25	28 "	Twice...........	" 8 " "	" fair
2508	" 28	......	....	....	" unfavorable
2515	" 28	30 "	June 23, July 15, Aug. 10	" 8 " "	" "
2516	" 28	30 "	....	" 8 " "	Stand excellent, season unfavorable
2517	Oct. 1	18 "	None............	" 8 " "	Season favorable
2525	" 3	20 "	June 20, July 25..	" 8 " "	" unfavorable
2532	" 10	20 "	None............	" 6 " "	" "
2539	" 16	20 "	July 1, Aug. 10, Aug. 15	" 8 " "	" "
2547	" 22	20 "	Twice...........	" 8 " "	Planted too late
2550	" 26	24 "	....	" 8 " "	Season fair
2551	" 24	24 "	Frequent.........	....	" "
2552	" 22	30 "	Twice...........	" 10 " "	" unfavorable
2553	" 26	16 "	June 10, Aug. 12, Sept. 8.........	" 10 " "	" fairly good
2554	" 26	28 "	Once in June.....	" 8 " "	" fair
2555	" 26	16 "	June 10, Aug. 12, Sept. 8.........	" 10 " "	" very unfavorable
2562	" 29	32 "	Not irrigated.....	" 6 " " No subsoiling ..	" fair
2563	" 29	18 "	June 21, July 5, Aug. 12	Plowed 7 in. deep.	" favorable

EXPERIMENT STATION,—VARIETY TESTS.

	Lab. No.	Date Harvested.	Variety.	Average Weight.	Per Ct. Sugar in juice	Per Ct. Sugar in beet
Plat 1	2493	Sept. 19	Zehringen, No 3942	14.6 oz.	14.2	13.5
" 2	2494	" 19	Kleinwanzlebener	14.6 oz.	15.5	14.7
" 3	2495	" 19	Vilmorin	12.3 oz.	15.0	14.3
" 4	2496	" 19	Strandes	14.6 oz.	13.6	12.9
" 5	2497	" 19	Braune, No 2885	15.1 oz.	11.7	11.1
" 9	2498	" 19	Hoerning	12.6 oz.	12.4	11.8
Plat 1	2509	Sept. 26	Zehringen, No 3842	15.8 oz.	13.7	13.0
" 2	2510	" 26	Kleinwanzlebener	14.6 oz.	14.2	13.5
" 3	2511	" 26	Vilmorin	14.7 oz.	12.5	11.9
" 4	2512	" 26	Strandes	1 lb 2.3 oz.	14.5	13.8
" 5	2513	" 26	Braune, No 2885	1 lb	11.8	11.2
" 5	2514	" 26	Hoerning	1 lb 2 oz.	11.8	11.2
Plat 1	2519	Oct. 3	Zehringen, No 3942	1 lb 1.1 oz.	16.8	16.0
" 2	2520	" 3	Kleinwanzlebener	1 lb 2.6 oz.	17.0	16.2
" 3	2521	" 3	Vilmorin	15.5 oz.	15.4	14.6
" 4	2522	" 3	Strandes	15 oz.	14.6	13.9
" 5	2523	" 3	Braune, No 2885	14.8 oz.	13.1	12.5
" 6	2524	" 3	Hoerning	1 lb 3.1 oz.	13.4	12.6
Plat 1	2526	Oct. 10	Zehringen, No 3942	14 oz.	17.2	16.3
" 2	2527	" 10	Kleinwanzlebener	1 lb 2 oz.	15.7	14.9
" 3	2528	" 10	Vilmorin	1 lb 3 oz.	14.9	14.2
" 4	2529	" 10	Standes	1 lb	16.4	15.6
" 5	2530	" 10	Braune, No 2885	15 oz.	14.7	14.0
" 6	2531	" 10	Hoerning	1 lb 0.3 oz.	15.5	14.7
Plat 1	2533	Oct. 17	Zehringen, No 3942	12.3 oz.	20.1	19.1
" 2	2534	" 17	Kleinwanzlebener	1 lb 0.6 oz.	17.1	16.3
" 3	2535	" 17	Vilmorin	1 lb	17.0	16.2
" 4	2536	" 17	Strandes	1 lb 0.6 oz.	17.3	16.4
" 5	2537	" 17	Braune, No 2888	1 lb 1.0 oz.	14.6	13.9
" 6	2538	" 17	Hoerning	1 lb 3 oz.	15.5	14.7
Plat 1	2541	Oct. 24	Zehringer, No 3942	1 lb 3 oz.	18.5	17.6
" 2	2542	" 24	Kleinwanzlebener	1 lb 3.6 oz.	18.4	17.5
" 3	2543	" 24	Vilmorin	1 lb 3.0 oz.	17.7	16.8
" 4	2544	" 24	Strandes	1 lb 2.8 oz.	15.8	15 0
" 5	2545	" 24	Braune, No 2885	1 lb 3.8 oz.	15.7	14.9
" 6	2546	" 24	Hoerning	1 lb 11.3 oz.	14.5	13.8
Plat 1	2556	Oct. 30	Zehringen, No 3942	14.3 oz.	19.0	18.1
" 2	2557	" 30	Kleinwanzlebener	1 lb 4.5 oz.	16.8	16.0
" 3	2558	" 30	Vilmorin	14.3 oz.	17.9	17.0
" 4	2559	" 30	Strandes	13.0 oz.	17.8	16.9
" 5	2560	" 30	Braune, No 2885	12.7 oz.	16.5	15.7
" 6	2561	" 30	Hoerning	1 lb 3.7 oz.	16.1	15.3

EXPERIMENT STATION—Variety Tests Continued.

Laby. No.	Per Ct. Total Solids in Juice	Purity.
2493	17.9	79.3
2494	18.9	82.
2495	18.5	81.1
2496	18.0	75.6
2497	15.3	77.1
2498	17.8	69.7
2509	17.1	80.1
2510	17.7	80.2
2511	16.1	71.4
2512	18.1	80.1
2513	15.3	77.1
2514	15.5	76.1
2519	20.1	83.6
2520	20.3	83.7
2521	19.5	79.
2522	18.0	81.1
2523	16.9	77.5
2524	16.9	79.3
2526	21.1	81.
2527	20.1	78.1
2528	18.3	81.4
2529	19.9	82.4
2530	18.2	80.8
2531	18.8	82.4
2533	22.7	88.1
2534	20.1	85.1
2535	19.7	86.3
2536	19.8	87.3
2537	18.1	80.6
2538	18.4	84.2
2541	21.7	85.2
2542	21.4	85.9
2543	21.2	83.5
2544	19.0	83.2
2545	19.0	82.6
2546	17.9	81.0
2556	21.3	89.2
2557	19.4	86.6
2558	20.9	85.6
2559	20.8	85.6
2560	20.2	81.6
2561	19.4	82.9

VARIETY TESTS. EXPERIMENT STATION. CULTURE NOTES.

	Variety	Planted	Irrigated	Thinned	Yield
Plat 1	Zehringen, No. 3942	May 26	July 3 and 4 about 3 in. deep; Aug. 1, 2 in. deep	June 1 and 15	Stand very good, 1872 lbs.
" 2	Kleinwanzlebener	" 26	July 5 and 4 about 3 in. deep; Aug. 1, 2 in. deep	June 1 and 15	1992 lbs., stand very good
" 3	Vilmorin	" 29	July 3 and 4 about 3 in. deep; Aug. 1, about 2 in. deep	June 1 and 15	1632 lbs., stand only fair
" 4	Strandes Kleinwanzlebener	" 29	July 3 and 4 about 3 in. deep; Aug. 1, about 2 in. deep	June 1 and 15	1368 lbs., stand only fair
" 5	Braune, No. 2885	" 29	July 3 and 4 about 3 in. deep; Aug. 1, about 2 in. deep	June 1 and 15	892 lbs., stand only fair
" 6	Hoerning improved Kleinwanzlebener	" 29	July 3 and 4 about 3 in. deep; Aug. 1, about 2 in. deep	June 1 and 15	1392 lbs., stand only fair

EXPERIMENT STATION TESTS

Effects of Degree of Maturity on Weight, Richness and Purity of Beets. All Varieties Averaged Together

Date harvested	Average weight	Average per cent. sugar in juice	Average per cent. sugar in beets	Average of total solids in juice	Average purity, per cent.
Sept. 19	13.9 oz	13.7	13.0 oz	17.7	77.4
" 26	16.2 "	13.1	12.4 "	16.6	77.5
Oct. 3	16.6 "	15.0	14.3 "	18.6	80.7
" 10	16.4 "	15.7	14.9 "	19.4	81.0
" 17	16.3 "	16.9	15.9 "	19.8	85.3
" 24	20.4 "	16.7	15.8 "	20.0	83.6
" 30	15.7 "	17.3	16.4 "	20.3	85.3

EXPERIMENT STATION. VARIETY TESTS. VARIETY AVERAGES.

Date harvested	Average weight	Average per cent. sugar in juice	Average per cent. sugar in beets	Average of total solids in juice	Average purity, per cent.
Zehringen, No. 3942					
Sept. 19	14.6 oz	14.2	13.5	17.9	79.3
" 26	15.8 "	13.7	13.0	17.1	80.1
Oct. 3	17.1 "	16.8	16.0	20.1	83.6
" 10	14.0 "	17.2	16.3	21.1	81
" 17	12.3 "	20.1	19.1	22.7	88.1
" 24	19.0 "	18.5	17.6	21.7	85.2
" 30	14.3 "	19.1	18.1	21.3	89.2
Totals	107.1 oz	119.6	113.6	141.9	586.5
Averages	15.3 "	17.1	16.2	20.2	83.8
Kleinwanzlebener					
Sept. 19	14.6 oz	15.5	14.7	18.9	82
" 26	14.6 "	14.2	13.5	17.7	80.2
Oct. 3	18.6 "	17.0	16.2	20.3	83.7
" 10	18. "	15.7	14.9	20.1	78.1
" 17	16.6 "	17.1	16.3	20.1	85.1
" 24	19.6 "	18.4	17.5	21.4	85.9
" 30	20.51 "	16.8	16.0	19.4	86.6
Totals	122.5 oz	114.7	109.1	137.9	581.6
Averages	17.5 "	16.4	15.6	19.7	83.1
Vilmorin					
Sept. 19	12.3 oz	15	14.3	18.5	81.1
" 26	14.7 "	12.5	11.9	16.1	71.4
Oct. 3	15.5 "	15.4	14.6	19.5	79.0
" 10	19. "	14.9	14.2	18.3	81.4
" 17	16. "	17	16.2	19.7	86.3
" 24	19. "	17.7	16.8	21.2	86.5
" 30	14.3 "	17.9	17.0	20.9	85.6
Totals	110.8 oz	110.4	105.0	134.2	568.3
Averages	15.8 "	15.8	15.0	19.2	81.2

VARIETY AVERAGES.—Concluded.

Date harvested	Average weight	Average per cent. sugar in juice	Average per cent. sugar in beets	Average of total solids in juice	Average purity, per cent.
Strandes					
Sept. 19	14.6 oz	13.6	12.9	18	75.6
" 26	18.3 "	14.5	13.8	18.1	80.1
Oct. 3	15.0 "	14.6	13.9	18.0	81.1
" 10	16.0 "	16.4	15.6	19.9	82.4
" 17	16.6 "	17.3	16.4	19.8	87.3
" 24	18.8 "	15.8	15.0	19.0	83.2
" 30	13.0 "	17.8	16.9	20.8	85.6
Totals	112.3 oz	110.0	104.5	133.6	575.3
Averages	16.0 "	15.7	14.9	19.1	82.2
Braune, No. 2885					
Sept. 19	15.1 oz	11.7	11.1	15.3	77.1
" 26	16. "	11.8	11.2	15.3	77.1
Oct. 3	14.8 "	13.1	12.5	16.9	77.5
" 10	15. "	14.7	14.0	18.2	80.8
" 17	17. "	14.6	13.9	18.1	80.6
" 24	18.8 "	15.7	14.9	19.0	82.6
" 30	12.7 "	16.5	15.7	20.2	82.9
Totals	109.4 oz	98.1	93.3	123.0	558.6
Averages	15.6 "	14.0	13.3	17.6	79.8
Hoerning					
Sept. 19	12.6 oz	12.4	11.8	17.8	69.7
" 26	18. "	11.8	11.2	15.5	76.1
Oct. 3	19.1 "	13.4	12.6	16.9	79.3
" 10	16.3 "	15.5	14.7	18.8	82.4
" 17	19. "	15.5	14.7	18.4	84.2
" 24	27.3 "	14.5	13.8	17.9	81.0
" 30	19.7 "	16.1	15.3	19.4	81.9
Totals	132.0 oz	99.2	94.1	124.7	559.6
Averages	18.8 "	14.2	13.4	17.8	80.0

EXPERIMENT STATION. VARIETY TESTS.—Season of 1901.

Laboratory No.	Variety	Average weight, oz.	Sugar in juice	Sugar in beet	Purity Coef.	Date harvested
1805	Miscellaneous	20.00	16.8	15.96	84.44	Sept. 19
1831	Kleinwanzlebener, No. 5770	24.8	15.8	15.3	81.00	" 28
1832	Utah Seed	25.4	16.5	15.67	85.5	" 28
1833	Zehringen, No. 3942	16.8	15.6	14.82	88.2	" 28
1834	Braune, No. 2885	23.00	16.1	15.19	83.3	" 28
1835	Kleinwanzlebener Dippe, No. 3944	19.6	16.3	15.58	82.02	" 28
1836	Kleinwanzlebener Russia, No. 3943	23.4	15.00	14.25	78.00	" 28
1837	Vilmorin	20.2	15.8	15.01	79.7	" 28
1838	Unknown variety	20.4	16.6	15.77	85.5	" 28
1842	Kleinwanzlebener No. 5770	20.5	16.1	15.29	76.3	Oct. 5
1843	Utah Seed	21.00	17.9	17.00	87.5	" 5
1844	Zehringen, No. 3942	22.00	15.9	15.10	74.6	" 5
1845	Braune, No. 2885	20.00	17.7	16.71	82.3	" 5
1846	Kleinwanzlebener Dippe, No. 3944	19.00	19.5	18.52	88.6	" 5
1847	Kleinwauzlebener Russia, No. 3943	18.00	17.6	16.72	86.1	" 5
1848	Vilmorin	26.5	14.00	13.3	72.9	" 5
1869	Kleinwanzlebener, No. 5770	25.5	17.0	16.15	86.00	" 12
1870	Utah	17.00	18.5	17.57	84.9	" 12
1871	Zehringen, No. 3942	15.5	18.3	17.38	83.3	" 12
1872	Braune, No. 2885	16.5	18.5	17.57	86.3	" 12
1873	Kleinwanzlebener Dippe, No. 3944	14.00	19.1	18.14	90.5	" 12
1874	Kleinwanzlebener Russia, No. 3743	14.5	18.6	17.67	88.5	" 12
1875	Vilmorin	17.00	19.2	18.24	87.6	" 12
1882	Kleinwanzlebener, No. 5770	15.00	18.4	17.48	82.9	" 19
1883	Utah	18.00	19.3	18.33	86.1	" 19
1884	Zehringen, No. 3942	14.66	20.00	19.00	87.00	" 19
1885	Braune, No. 2885	16.66	19.9	18.9	87.6	" 19
1886	Kleinwanzlebener Dippe, No. 3944	18.66	18.3	17.38	85.9	" 19
1887	Kleinwanzlebener Russia, No. 3943	14.66	18.2	17.29	86.6	" 19
1888	Vilmorin	17.00	17.9	17.00	84.00	" 19
1966	Kleinwanzlebener, No. 5770	20.8	17.90	17.00	81.8	" 26
1967	Utah	17.4	20.10	19.05	85.00	" 26
1968	Zehringen, No. 3942	20.00	19.70	18.76	85.5	" 26
1969	Braune, No. 2885	21.00	19.70	18.74	87.00	" 26
1970	Kleinwanzlebener Dippe, No. 3944	23.00	19.50	18.46	88.00	" 26
1971	Kleinwanzlebener Russia, No. 3943	19.00	19.30	18.35	87.5	" 26
1972	Vilmorin	22.00	17.97	17.01	86.00	" 26

AVERAGES OF ALL TESTS. EXPERIMENT STATION.—Season of 1901

Variety	Average weight, oz.	Sugar in juice, per cent.	Sugar in beet, per cent.	Purity Coef.	Tons per acre	Lbs. sugar per acre
Kleinwanzlebener, No. 5770	21.32	17.04	16.31	81.6	13.5	4403
Utah	19.76	18.44	17.51	85.8	11.7	4007
Zehringen. No. 3942	17.8	17.91	17.01	83.7	11.45	3895
Braune, No. 2885	19.43	18.38	17.42	85.3	10.5	3658
Kleinwanzlebener Dippe, No. 3944	18.85	18.53	17.61	87.00	10.4	3662
Kleinwanzlebener Russia, No. 3943	17.91	17.75	16.85	85.3	9.25	3117
Vilmorin	20.5	17.13	16.27	84.00	9.5	3091
General average	19.37	17.88	16.98	84.9	10.9	3690

AVERAGES FOR SUCCESSIVE DATES. EXPERIMENT STATION.—
Season of 1901

Date	Average weight	Per cent. sugar in juice	Per cent. sugar in beet	Per cent. purity
Sept. 28	21.7 oz	15.96	15.20	82.90
October 5	21.0 "	16.96	16.13	81.19
" 12	17.14 "	18.46	17.53	86.73
" 19	16.38 "	18.86	17.92	85.73
" 26	20.45 "	19.18	18.25	85.83

RESULTS IN 1901.—CLARK'S FORK VALLEY.—BRIDGER AND GEBO.

The * indicates that the P. O. address is Gebo; the address of all others is Bridger.

Laboratory No.	Name	Average weight in oz.	Sugar in juice	Sugar in beet	Purity Coef.	Tons beets per acre	Lbs. sugar per acre
1850	P. R. Miller*	8.8	17.1	16.22	79.9	6.5	2108
1854	C. F. Sexton	29.00	15.9	15.10	80.3	25.00	7552
1881	A. E. Parker	31.5	14.3	13.58	69.4	9.00	2444
1889	William Barclay	14.7	16.2	15.39	78.2	12.00	3695
1891	James Barclay	19.43	21.3	20.23	82.88	20.00	8092
1903	C. M. Larkin	10.8	16.88	16.00	80.00	......	......
1907	W. H. Bostic	24.9	19.5	18.52	78.3	20.00	7408
1934	C. H. Bostic	9.4	15.5	14.72	67.1	......	......
1935	W. F. Gibson	35.5	18.00	17.1	74.4	24.00	8208
1936	Lucy H. Smith	28.00	20.1	19.09	83.7	20.00	7636
1937	Hugh Morrow	26.5	19.7	18.71	74.5	15.00	5613
1938	R. B. Teesdale	......	18.8	17.86	85.4	25.00	8930
1939	E. T. Bostic	28.50	21.9	20.8	88.3	......	......
1940	J. R. Stevens	55.0	14.81	14.06	77.4	15.00	4218
1941	S. H. Mendenhall	14.8	18.11	17.2	83.8	20.00	6880
1942	Thomas Barnett	20.8	16.5	15.67	80.00	12.00	3760
1943	A. G. Duffield	32.00	17.8	16.9	83.00	25.00	8450
1944	L. G. Preno	24.5	17.9	17.00	79.6	20.00	6800
1945	F. O. Jennings	31.00	17.6	16.7	75.00	......	......
1946	B. F. Bayler	33.00	22.7	21.56	85.3	......	......
1947	Richard Barrows	25.5	18.6	17.67	82.00	20.00	7068
1952	I. A. Goff *	11.6	13.4	12.73	74.44	12.00	3055
1953	F. E. Stevens	21.00	16.00	15.20	82.05	25.00	7600
1954	Frank Hiser	9.2	19.3	18.33	84.65	15.00	5499
1955	E. D. Lovegreen	14.33	16.3	15.48	77.94	15.00	4644
1956	E. T. Preuitt	18.66	19.1	18.14	86.80	20.00	7256
1957	W. A. Cowan*	21.00	16.8	15.96	80.00	......	......
1958	E. Cowan	15.4	19.8	18.81	90.00	20.00	7524
1959	N. Webber	18.6	18.7	17.76	86.12	......	......
1960	C. M. Laughery	17.5	19.9	18.90	88.83	20.00	7560
1961	T. E. Stearns	18.66	14.7	13.96	76.96	......	......
1950	R. A. Duncan †	25.00	17.7	16.8	80.00	......	......

† P. O. address is Rockvale.

RESULTS IN 1901.—BITTER ROOT STOCK FARM.—HAMILTON, MONTANA

Laboratory No.	Locality	Average weight in oz.	Sugar in juice	Sugar in beet	Purity Coef.	Tons beets per acre	Lbs. sugar per acre
1855	Hamilton Ranch, No. 1	17 8	20.1	19.09	87.3	18.9	7216
1856	Hamilton Ranch, No. 2	16.6	19.3	18.33	86.9	13.6	4985
1857	Hamilton Ranch, No. 3	15.2	20.1	19.9	82.4	22.00	8756
1858	Hamilton Ranch, No. 4	8.8	21.1	20.04	87.5	12.7	5090
1859	Gilchrist Ranch, No. 1	11.00	20.6	19.57	88.4	18.4	7201
1860	Gilchrist Ranch, No. 2	11.6	22.00	20.9	91.2	......	......
1861	Prendergast Ranch, No. 1	11.8	19.8	18.81	87.6	20.00	7524
1862	Prendergast Ranch, No. 2	13.6	22.1	20.99	92.00	18.00	7556
1863	Lower Ward Ranch, No. 1	13.00	21.1	20.04	90.6	18.3	7334
1864	Lower Ward Ranch, No. 2.	12.4	20.8	19.76	89.2	14.00	5532
1865	Upper Ward Ranch, No. 1	13.4	20.3	19.28	87.5	12.00	4627
1866	Ravalli Ranch	13.00	20.2	19.19	90.00	14.6	5603
1867	Corvallis Ranch	15.6	20.4	19.38	86.4	25.6	9922

LOCALITY AVERAGES FOR 1901

Locality	Average weight in oz.	Sugar in juice	Sugar in beet	Purity Coef.	Tons beets per acre	Lbs. sugar per acre
Cascade County (1)	24.5	16.25	15.4	75.4	25.00	8075
Yellowstone County	35.66	10.50	10.00	62.6	......	......
Flathead County	16.45	18.9	17.95	82.24	12.8	4520
Valley County (1)	19.40	15.2	14.43	82.7	20.00	5968
Park County (2)	19.5	16.66	15.94	73.07	20.5	6498
Custer County (1)	16.00	18.4	17.5	78.00	......	......
Dawson County (1)	18.6	14.00	13.3	76.5	......	......
Powell County	21.9	15.6	14.86	81.8	......	......
Fergus County	17.00	15.4	14.63	71.6	23.00	7552
Jefferson County	23.00	13.50	12.82	83.00	......	......
Carbon County (3)	29.2	13.9	13.2	66.5	16.00	4244
Missoula County	16.7	17.3	16.46	83.00	13.00	4288
Ravalli County (4)	16.8	17.8	16.96	82.45	......	......
Gallatin County (5)	22.88	15.46	14.68	78.9	31.00	9332
Bitter Root Stock Farm	13.37	20.60	19.64	87.46	16.5	6771
Experiment Farm	19.37	17.88	16.98	84.9	10.9	3690
Clark's Fork Valley	22.7	17.84	16.97	80.5	18.00	6174

(1). One lot only.
(2). One locality only.
(3). Excluding Clark's Fork Valley.
(4). Excluding Bitter Root Stock Farm.
(5.) Excluding Experiment Farm.

On the whole the results of the experiments in 1903 are unsatisfactory. This view is forced upon one after a study of the results in preceding years, especially those of the year 1901, some of which are included in this bulletin for comparison with the work of the past season.

These results are due largely to the fact that even less interest than usual has been given to the culture of beets during the past year. This lack of interest is due mainly to the fact that notwithstanding the excellent results obtained in the past, no market for beets, through the establishment of a factory in Montana, has yet been made, and in consequence beets have received but scant attention.

It is said that "figures speak for themselves," and certainly the results presented show that under proper attention Montana can hold its own as a beet sugar producing state.

With the figures presented for many years past by the Montana Experiment Station, why is it that we are not producing our own sugar?

I am indebted to "Beet Sugar Points," and to articles by Mr. Thomas Tonge for much of the matter of a general nature introduced into this bulletin, to Prof. Linfield, Agriculturist of the Station, for supervision of the variety tests, and to Mr. Edmund Burke, assistant chemist, for the analytical work on all the beets submitted.

For additional information concerning results obtained in Montana in former years, readers of this bulletin are referred to Bulletins 19, 33 and 41 of the Montana Experiment Station.

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MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

F. B. LINFIELD, DIRECTOR.

BULLETIN NO. 53.

CREAMERIES AND CHEESE FACTORIES:

ORGANIZATION, BUILDING AND EQUIPMENT

Dairy Building—Montana Experiment Station.

BY

W. J. ELLIOTT,
Assistant Dairyman.

BOZEMAN, MONTANA:
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MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION.

BOZEMAN, MONTANA.

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THE MONTANA EXPERIMENT STATION,
Bozeman, Montana.

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Montana Experiment Station.

Bulletin No. 53.

CREAMERIES AND CHEESE FACTORIES

THEIR ORGANIZATION, BUILDING AND EQUIPMENT.

Dairying can scarcely be said to be an industry in Montana, though the natural facilities, climate, soil, water and feed, as well as the market, are very favorable indeed. Montana probably offers as good prices for dairy products as any state in the Union and very much better than most of the states, yet there are millions of pounds of butter and cheese imported into the state annually. There are probably several reasons for this. As a rule the farms in Montana are large and much hired help has to be depended upon. The successful herd requires the careful supervision of the owner which is generally possible only on the smaller farms. Montana farms are productive and her farmers have been content with the smaller returns rather than undertake the more exacting demands of dairy work. The profitable dairy herd produces milk the year round and some of the cows have to be milked 365 days in the year, morning and evening. Though the income is substantial many will not try to increase it at the cost of the extra tax on their time and attention.

That the dairy industry may be attended with marked success in Montana, there is ample evidence to prove. A dairy herd in the Gallatin valley last year returned its owner $65 from each cow, The feed at market prices cost not to exceed $30 for each cow. On this basis, by selling the feed to the cows the returns of the farm were more than doubled as compared to selling the crop off the farm. These returns indicate a good dairy herd, but that is the only kind with which a person should attempt the business.

ADVANTAGES OF DAIRYING.

When we consider that the value of the dairy products in the United States amounts to the enormous sum of four hundred and fifty million dollars each year, we see at once that it is one of the largest branches of agriculture. Its advantages to those engaging in it are many. In the first place it is a cash business and also a business from which there is a little ready money coming in all the year round, which is infinitely better, both for the farmer and the merchant, than having one to two pay days a year, for instance, when the grain is threshed and drawn to market, or live stock sold. Another point is that it gives employment all the year round. Just think of the exclusive grain growing practice for a moment and note how all the work of the year is rushed into a few weeks in the hottest part of the summer, when it is almost impossible to get competent help. Right there is where the dairy industry is a boon to the farmers' sons. It gives them something that pays well for their time and employment all the year round. In other words, it keeps the farmer and his family busy. They do not need to seek employment in the city. It keeps the boy on the farm.

Another advantage of the dairy industry for Montana is that there are not long freight hauls to market. There is an unlimited market right at home, with prices for butter and cheese that excel those of almost any other state in the Union. In addition there is a fine climate, pure water, and as good feed as can be grown anywhere. All these are prime essentials for high quality butter and cheese.

One of the questions that we generally meet with is, "What is the use of starting a creamery to make more butter, when we cannot find a market for that which we are making on our ranches now?" The reason that a ready market cannot be found for the ranch butter is simply because it is hard to find any two lots of butter in a community that are exactly the same in every respect. But where all the farmers bring their cream or milk to a central plant, and have a skilled butter or cheese maker turn out a uniform article, there is not the least difficulty in disposing, right in our own state, of all the butter and cheese that fifty plants could turn out.

CAUTION.

We do not wish for a moment to give only the bright side of the dairy industry, tor there is a "work" side also. It is just like any other business. To make money out of it requires care and attention.

It requires care and selection in handling the cows, care in the feeding, care in the handling of the milk, and care over all these things for twelve months in the year.

But there is no other branch of farm work that will pay better, for the care and attention you give it, than the dairy business. Far better than selling the farm crops at the prevalent market prices, sell them through the cow and the milk pail, and you will realize just double market prices for your crop.

The creamery or cheese factory business like any other manufacturing business, requires a certain amount of raw material before the plant can be run successfully. A lack in the milk supply is perhaps the cause of more new creameries failing than any other. The first thing in starting a factory therefore is to find out if there is sufficient milk with which to keep the plant running the year round. Those interested must have an absolute guarantee of the milk from 300 cows for a creamery and 150 to 200 for a cheese factory, with prospects that this number will be increased as rapidly as possible in the near future. If the milk from about this number of cows cannot be guaranteed it will be good business to let the creamery project rest for a time. No creamery, however well equipped or managed, can make any money for its owners or patrons with but one to two thousand pounds of milk a day.

When the farmers own the plant and enter into a written contract with each other to supply the milk from the requisite number of cows, under good management the factory cannot fail to succeed.

Because of the above facts and of the large number of inquiries that are coming into the office, with reference to the building and equipping of creameries and cheese factories, it was thought advisable to prepare this bulletin, which we trust may be useful to those who are thinking of erecting such plants.

Plans and specifications are given for an up-to date creamery and cheese factory, and also complete lists of machinery for both. These plans we have found after ten years of practical work in such plants to be well adapted for the purpose, and not only that, but every article mentioned is necessary for the successful operation of either plant.

In the descriptions which follow the object has been to give clear and condensed plans and specifications, and also a complete list of machinery for an up-to-date, thoroughly equipped butter and cheese factory.

On the following pages will be found plans for what we consider a model creamery and cheese factory. These plans combine the best points of several creameries and cheese factories. Blue prints of these plans may be had on application to the Station.

ORGANIZATION OF CREAMERIES OR CHEESE FACTORIES.

If the required number of cows are found, within the prescribed limits, the next thing is organization.

Montana, Minnesota, North and South Dakota have laws which should be followed in forming corporations. The best plan is to have some attorney draw up the necessary corporation papers, if you desire to incorporate.

The laws of the state of Montana, however, permit the organization of cooperative creameries and cheese factories without the necessity of incorporating. Any attorney can draw up the necessary agreement, or you will find elsewhere in this bulletin a copy of agreement, constitution and by-laws, that are recommended.

FORM YOUR OWN ORGANIZATION.

By all means, however, form your own organization, and do not be led by the agent of any creamery supply house into a plan whereby he organizes you into a company, builds your creamery, equips it and turns it over to you in complete running order. This is the rock on which most of the creameries that have failed have

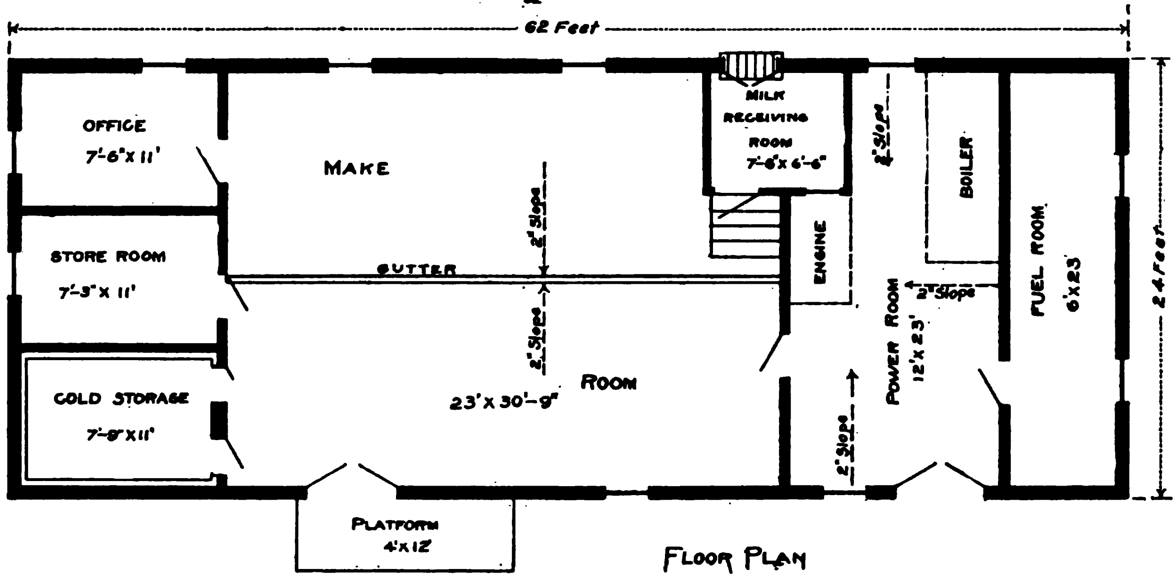
PLAN OF CREAMERY

RECOMMENDED BY THE DAIRY DEPARTMENT OF THE

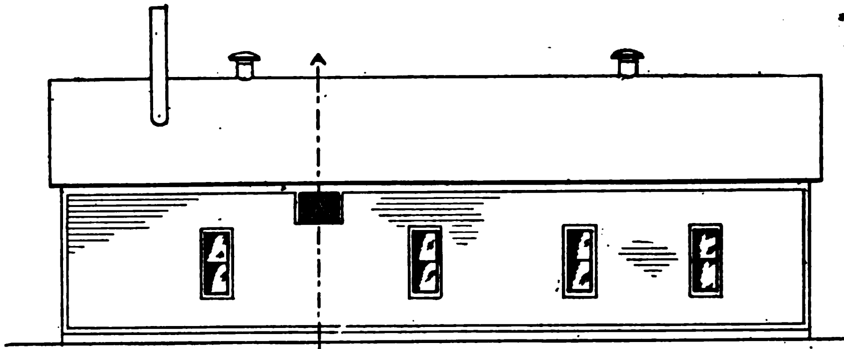
MONTANA AGRICULTURAL EXPERIMENT STATION

BUILDING 62'X 24'

Scale 3/32" = 1'

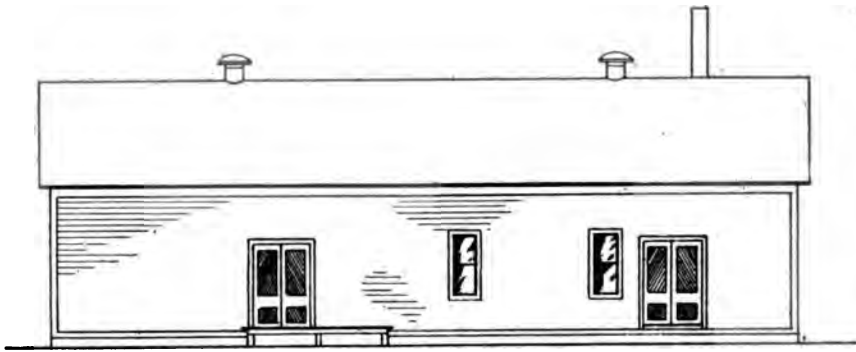


FLOOR PLAN



SIDE ELEVATION

PLAN OF CREAMERY
Scale $\frac{1}{16}'' = 1'$



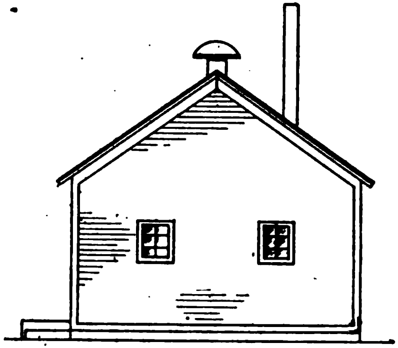
SIDE ELEVATION

G.T.M.

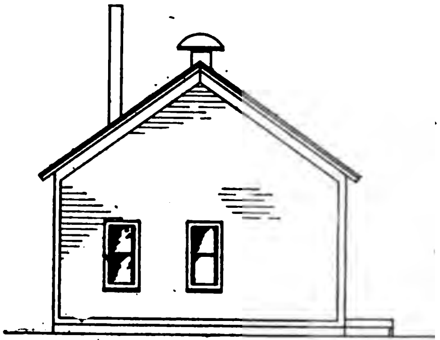
Plan of Creamery

Hight of Ceiling 12', $\frac{1}{3}$ Pitch

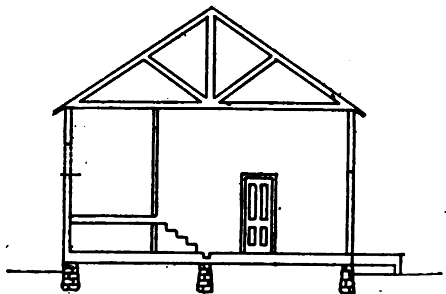
Scale $\frac{1}{16}'' = 1'$



Rear End Elevation



Front End Elevation.



Cross Section on A-B

split. The agricultural and dairy papers have for years been teeming with exposures of this swindle of ready built creameries; but every year seems to find a new crop of people ready to bite. And the consequence is the country is dotted with expensive worthless creameries standing idle.

The leading creamery supply houses do not undertake to organize and build a creamery. Their business is to furnish the machinery only, but there are one or two houses that have agents constantly going through the country offering to work up a creamery company in any neighborhood, soliciting stock and getting up the articles of incorporation, building the creamery and equipping it and turning it over to an association of farmers at a given price.

This, of course, seems like a very nice way, as it relieves the members of the creamery association of all the preliminary work and the organization of the creamery, but you can rest assured no one is going to do this work for nothing, and no outside parties can do this as cheaply and effectively as you can do it yourselves.

When any man comes along offering to organize a creamery company, solicit stock, draw the papers, build the building, and equip it, turning it over to you a ready built creamery, and taking all the work of organization off your hands, look with suspicion upon the project. He isn't working for his health, but is doubtless drawing a big salary to do work you can just as well do yourselves. No outside company can go into a neighborhood and spend the time necessary to work up a company, build and equip a creamery, pay salaries, traveling expenses and hotel board for nothing, and they usually get a good large profit on top of the expenses made. Therefore, we repeat, ***form your own organization, and build the creamery yourselves.***

Keep your business in your own hands and don't sign away your rights to organize and build your own business and give the benefit of what profit there may be in it to others.

HOW TO RAISE THE MONEY.

The old plan for building factories was for each patron to take one or more shares of stock, paying the cash for them. In many

instances it has been found difficult to raise the money under this plan, as many desirable patrons were unable to raise the amount of cash required to build and equip the plant.

To overcome this difficulty a plan was devised which has been used by a great many companies with very satisfactory results. This plan is as follows: Let each patron of the proposed creamery sign an agreement similar to that drawn on page 68 marked "Organization Agreement," signing his name and the number of cows he will agree to milk for the creamery or cheese factory.

You will notice this agreement provides for borrowing the amount of money necessary to build the creamery, and that each person signing the agreement agrees to be personally responsible for the payment of the sum borrowed.

There is hardly a community in the state in which some one cannot be found to loan $2500 (cheese factory) to $4500 (creamery) to an association of twenty-five or fifty or more, farmers each one of whom agrees to be personally responsible for the loan.

When the required number of patrons and cows have been secured, call a meeting of the patrons and perfect the organization, by adopting and signing articles of agreement.

We give on page 68 articles of agreement and by-laws which have been used in a great many creameries and cheese factories and have been found very satisfactory. Of course such changes could be made in these as might be desired.

You will notice that Article Two of the by-laws provides that 5 cents on each hundred pounds of milk received at the creamery shall be retained to form a sinking fund to be used to pay off the money borrowed, and that Article Four of the agreement authorizes the board of directors to borrow the sum required, the loan to be paid back out of the sinking fund as fast as it accumulates.

This plan enables the creamery company to start without the individual patrons being required to raise the cash; and at the same time it gives the creamery the ready cash to buy their lumber, material and machinery so as to obtain the benefit of the lowest cash prices.

The five cents per hundred pounds that is deducted from the amount of milk taken to the creamery is not felt by the patrons, as

even after this is taken out they will get more out of their milk than they have been getting by making it into butter and cheese themselves, so the creamery is gradually paying for itself without expense to the patrons.

Under this plan a creamery that is receiving milk from 300 cows should be getting six thousand pounds of milk a day; if five cents per hundred of this went into the sinking fund, it would be three dollars a day; so that it would require from two years and a half to four years to pay off the loan, and have the creamery clear under this plan, on a creamery receiving the amount of milk stated. By this means also the factory is paid for and the patron practically does not feel it at all.

We give below a draft of organization agreement, articles of agreement, and by-laws which can be used as a guide and changed or modified as desired.

ORGANIZATION AGREEMENT.

We, the undersigned citizens of............county, State of Montana, do hereby agree to form themselves into an association to be known by the name of.............. Association, and we agree to borrow the sum of..........dollars or less, to put up a building and equip it with the necessary machinery, and jointly to become personally responsible for the sum borrowed including interest. The money to be raised in the manner agreed upon by the association. We also agree to furnish the milk from the number of cows opposite our names.

Name............................ Cows..................

ARTICLES OF INCORPORATION.

We, whose names are hereto subscribed, and whose residences are within the county of........................ in the state of Montana, do hereby associate ourselves together as a cooperative association under the laws of the state of Montana, to which we have adopted the following constitution, viz.:

ARTICLE I.

The name of the association will be the.....................
Association, and its place of business shall be at or near Section....
in the town of..............in said.............. county.

ARTICLE II.

The object of this Association shall be the manufacture of butter and cheese or both from whole milk, at actual cost.

ARTICLE III.

The officers of this Association shall be a President, Vice President, Secretary, Treasurer and three trustees, who shall be elected annually at the regular annual meeting of the Association to be held on the first Monday of January of each year, and their term of office shall be one year and until their successors shall have been duly elected and have qualified.

ARTICLE IV.

The duties of the respective officers shall be as follows: The President shall preside at all meetings of the Association. He shall have power to call special meetings of the Association whenever in his judgment required by the business of the Association or upon the written request of five or more members.

The Vice President shall perform the duties of the President when he is absent or otherwise unable to attend to them.

The Secretary shall keep a record of all the meetings of the Association, and make and sign all orders upon the Treasurer and pay over to the Treasurer all money which comes into his possession, taking the Treasurer's receipt therefor.

The Treasurer shall receive and receipt for all moneys belonging to the Association, and pay out the same only upon orders which shall be signed by the Secretarry. The Secretary and Treasurer shall give bonds in such amount as the Association shall provide.

The President, Vice President, Secretary and Treasurer and three trustees shall constitute the Board of Directors, whose duties shall be to audit and allow all just claims against the Association. They shall compute the amount of milk receipts, the amount of

product sold, and the moneys received therefor, and, after deducting from the total receipts the percentage herein provided for as a sinking fund and also the running expenses, on the 15th day of each month, divide the remaining receipts of the preceding month among the members and patrons of the Association, proportionately to the amount of whole milk or fat furnished by each. Provided, however, that in case of withdrawal of any member from this Association before the moneys herein provided to be borrowed shall have been paid in full, principal and interest, all product from milk furnished by such withdrawing members then on hand, and any moneys received from such product then in the possession of the Association, shall be retained until all said moneys so borrowed shall have been fully repaid, and thereafter said moneys, or any remainder thereof after applying the just share of such withdrawing members therefrom to the repayment of any balance of such indebtedness not paid from the sinking fund, shall be paid over to him or his assigns.

The Board of Directors shall cause the Secretary to make in writing, a report to the annual meeting of the Association, setting forth in detail the gross amount of milk receipts, the net amount of receipts from all products sold and all other receipts, the amount paid out for running expenses, the sums, if any, paid out for milk, and all other matters pertaining to the business of the Association. A like statement, containing the gross amount of milk receipts, the net receipts from products sold and all running expenses of the creamery shall be made each month and posted conspicuously in the creamery building at the time of the division of the prior month's receipts as aforesaid.

The Board of Directors shall borrow a sum of money not exceeding...........thousand dollars, to be used by them in the erection and completion and furnishing of the creamery building and for no other purpose. Said members of said board may borrow said money on their own responsibility, and in case they do so, then the sinking fund herein provided for shall by them be applied in payment of said borrowed moneys as the same fall due in the same manner as though said moneys had been borrowed by the Association. Said members of the board shall in such case be held to be

creditors of the Association to the amount of such moneys unpaid, and the several members of said Association shall be personally responsible, jointly and severally, for the same. Provided, however, that prior to any legal assertion of such individual responsibility, the entire sinking fund then accrued and on hand shall be applied upon such indebtedness. And, provided, further, that said members so borrowing said moneys may, if they so elect, demand and receive any part or all of the moneys received from the products sold then in the possession of the Association, upon such indebtedness before enforcing such personal responsibility. In which case only that part of such indebtedness remaining after applying thereon all sums so received shall be recovered or demanded from the members of the Association.

ARTICLE V.

The several members shall furnish all the milk from all the cows subscribed by each, all milk to be sound, fresh, unadulterated, pure and unskimmed, and patrons of the Association, not members, may by agreement with the Board of Trustees furnish such amounts of milk as may be agreed upon. The Association shall receive all such milk so furnished, manufacture the same into butter, cheese or other products, and sell and receive all moneys from the product; and from the moneys so received deduct such a percentage thereof or such a number of cents per one hundred pounds of milk as shall have been agreed upon by the Association in the by-laws or otherwise, and also deduct the running expenses of the creamery, the remainder thereof to be distributed as provided in Article IV hereof.

ARTICLE VI.

Each member shall be entitled to one vote only at any meeting of the Association. New members may be admitted as provided in the by-laws. Members shall be permitted to withdraw only as provided by the By-Laws.

ARTICLE VII.

The first officers and Board of Trustees shall be as follows:

....President;
....Vice President;
....Secretary;
....Treasurer;
....
....
....Trustees.

ARTICLE VIII.

These articles may be amended at any annual meeting, or at any special meeting called for that purpose, provided that two-thirds of all members present vote in favor of such change; and provided further, that at least one month's notice of such proposed amendment shall have been given in such manner as may be provided in the By-Laws, or otherwise by the Association.

BY-LAWS OF.............ASSOCIATION.

I.

The Secretary and Treasurer shall give bonds in the sum of ....dollars, both bonds to be approved by the Board of Directors.

II.

Five cents on each one hundred pounds of milk received at the creamery shall be reserved to form a sinking fund.

III.

No milk shall be received or business of any kind transacted at the creamery on Sundays.

IV.

During the interval between the 20th day of May and the 20th day of September of each season all milk shall be delivered at the creamery as early at least as nine o'clock a. m., during the remain-

ing portion of the season as early as ten o'clock a. m.

V.

All milk delivered shall be sweet and in good condition; and if any be found otherwise, the operator may condemn the same, and in such case he shall notify the president thereof. The operator shall preserve samples of every delivery of each patron's milk, testing the same at proper intervals on the composite testing plan.

VI.

Any member or patron of the Association found skimming, watering or in any manner adulterating his milk offered at the creamery shall forfeit to the Association as follows: For the first offense, ten dollars: for the second offense, twenty-five dollars; for the third offense, he or she shall forfeit all interest in the Association and also all claims for milk theretofore delivered to the Association. But no such forfeiture shall be adjudged without first affording to the member or patron charged with so having skimmed, watered or adulterated his milk, full opportunity to defend himself from such charge. Any member sending to the creamery any bloody or unhealthy milk, or any milk from any cow within four days after calving, shall, if convicted of having done so knowingly, forfeit as prescribed above in this section.

VII.

Members and patrons furnishing whole milk may take from the separator or tank at the creamery four-fifths of the quantity of milk (in pounds or quantity) delivered at the creamery by them on that day. Any member taking therefrom more than such amount shall forfeit to the Association the sum of five dollars for each such taking.

VIII.

Withdrawals from the Association shall be allowed only as follows: The member desiring to withdraw shall give at least one month's notice of his application therefor. Such application shall only be allowed on a vote of two-thirds of all members present and voting at any meeting or hearing at which such application shall

have been noticed. Provided, however, that any member living more than three miles by the nearest road from the creamery building, may make application to the Board of Directors, who, in their discretion, may grant permission to such member to withdraw from the Association.

IX.

Any member refusing to deliver at the creamery the amount agreed to be there delivered, shall, without reasons satisfactory therefor to the Association, forfeit all interest in the product on hand.

X.

Notice of any proposed amendment to the Constitution shall be in writing or printing and shall be kept posted prominently in the creamery building and also on the walls of the delivery department for the reception of milk.

LOCATING A CREAMERY.

There are four things to be considered in locating a creamery:

First, there must be on an average 300 cows, milking for three hundred and sixty-five days in the year, within a paying hauling radius of the creamery, (from 6 to 8 miles on each side of the creamery).

Second, there must be pure water.

Third, there must be good drainage.

Fourth, good roads by which the patrons may reach the factory are very essential.

GENERAL SPECIFICATIONS FOR CREAMERY.

1. *Trenches* shall be excavated for all walls, at least 1 foot below the natural surface of the ground.

2. *Stonework.* All foundations and piers to be rubble work, consisting of sound local stone laid in lime and sand mortar mixed to proper proportions. Sand to be clean, coarse and sharp. Lime, fresh local lime. All walls to be faced on outside, slushed up and neatly pointed. All walls to be well bonded with frequent headers, and the angles tied with through stone. Stonework to be 6 inches above ground at highest point. The contractor may at his option use concrete in place of stone work, of proportions hereinafter specified for concrete work.

3. *Cement Work.* All cement used to be standard grade cement. Engine and boiler room to have concrete floors. Also concrete foundation for separator, said foundation to be started 1½ feet below the natural surface of ground.

The concrete will be composed of one part cement and three parts sand and five parts broken stone and gravel, tamped in place until water shows on the surface.

Top coating will consist of one part cement and two parts clean sand, free from loam, to be put on before concrete is dry. Surface to be troweled smooth. There shall be proper slope to the concrete in engine and boiler room for drainage.

5. *Carpenter Work*, All two sash windows will be 1⅜ thick, pine or fir, and free from imperfections that may impair its strength.

Building to be substantially framed together and thoroughly nailed, using nails of suitable size.

Floor joists 2x10-16 inch on centers.

Rafters 2x6-24 inch on centers.

Studding 2x4-16 inch on centers.

All partition studding to be 2x4.

Plates 2x4 double.

Ceiling joists 2x6-24 inch centers.

Truss on every third rafter 1x6 tie and 2-1x6 studs.

5. *Sheeting.* Cover all outside walls as well as roof with 1"

inch surfaced sheeting well nailed to every bearing. On inside ceil up with No. 2 1x6 M. & D., all except coal room which is to be sheeted up with same material used for outside sheeting.

6. *Window Frames.* All sash windows will be 1⅜ thick and have frames with pockets for weights and good axle pulleys. There will be 2-inch sides, blind stops, pulley stiles, and outside casing. All windows except coal room to contain two lights 24x30, windows in coal room to be hung with 3x3 buts and to have hook fasteners.

7. *Roof.* Covered with 26 guage metal roof.

8. *Paper.* Under all roofing and siding cover sheeting with red rosin sized building paper, well lapped and brought up carefully to cornice and frames.

9. *Outside Finish.* All outside finish will be of No. 2 pine free from pitch and loose knots. Corner boards and base will be of 1-inch stuff. Cornice to consist of 1x8 frieze, 1x12 plancia, 1x4 facia, 3½ inch crown moulding and 2-inch bed mould.

All other outside finish will be No. 2, 6-inch rustic.

10. *Ventilators.* To consist of two good weather proof galvanized iron ventilators of at least 150 inch capacity each.

11. *Flooring.* 1x4 vertical grain Oregon fir over all except engine and boiler room and coal room.

Coal room to have no floor but leveled up with earth to the level of engine and boiler room floor.

There will be a gutter for drainage running the entire length of the make room floor, which will also drain the engine and boiler rooms as well as refrigerator room.

12. *Inside Finish.* All openings to be cased up with 1x4 No. 2 pine for paint.

13. *Doors.* All interior doors to be four panel 1⅜ inch No. 2 doors for paint with 2 feet 6 inch by 6 feet 8 inch openings. Double doors to be built up with 1¼ inch stiles and rails, halved intersections and covered on opposite side with No. 2 1x4 M. & D. and to have 5 feet by 7 feet opening. Double door in milk receiving room to have 2 feet 6 inch by 3 feet opening.

14. *Sash.* All sash will be of pine 1⅜ inch thick and glazed with two 24 inch by 30 inch lights as shown, with good quality

window glass. All double windows to be hung with cast iron weights to balance with braided sash cord.

15. *Stairs inside* to raise 3 feet to milk receiving room with 7¼ inch raise and 9 inch breadth steps.

16. *Hardware*. All outside double doors to have head and foot bolts and good thumb latch and No. 42 Yale cylinder night latch.

Interior doors to have mortised knob locks with long escutcheon and jet knobs.

All sliding windows to have 2 sash lifts and Ives sash lock, Berlin bronze finish.

17. *Painting*. Roof to have two coats of mineral paint. All outside woodwork to have two good coats of strictly pure lead and oil paint, colors to suit.

Inside, with exception of coal room, to have two good coats of paint, colors to be selected.

COST OF BUILDING.

The cost of this building will vary slightly, according to the local cost of material in the particular locality.

We submitted these plans to a contractor who figured lumber from the following prices:

2x4, 2x6, 2x10	$17.50 per 1000.
Sheeting	17.50 per 1000.
1x4	22.00 per 1000.
1x6	25.00 per 1000.
No. 2 ship lap or rustic	26.00 per 1000.
Oregon fir	35.00 per 1000.
Window frames	$1.25 to $2.50 each.
Doors 2 ft. 6 in. x 6 ft. 8 in.	$3.50.
2 ft. 8 in. x 6 ft. 8 in.	$4.00.

The contractor's figure on this building was $2000 to $2200 finished according to foregoing plans and specifications, $2000 being a safe estimate in most localities.

MACHINERY FOR CREAMERY.

A great many firms in outlining the machinery for a plant only give a list of the larger and more important parts of the machinery and never mention the large number of smaller things that are absolutely necessary in the creamery. Take for example such things as salt, oil for engine, cylinder and cream separator, butter color, extra brushes, parchment wrapping paper, shipping boxes or tubs, radiators, pails, etc

The following is a complete list of everything in the line of machinery, equipment and supplies needed to begin running a creamery.

LIST OF MACHINERY.

1 20-H. P. horizontal boiler, complete with all fixtures including door, grate bars, bearing bars, pop valve, steam guage and syphon, water column with glass water gauge, 3 guage cocks, feed, check and blow-off valves, injector fitted to boiler, whistle, smoke stack and saddle, guy wires, flue cleaner, poker ,coal scoop, etc.

400 fire brick.

1 barrel fire clay.

1 15-H. P. horizontal engine with brass oiler and Detroit lubricator.

1 boiler feed pump with lubricator.

1 4x6 steam well pump.

1 Separator of 3,000 pound capacity per hour.

1 Churn, working capacity 600 pounds butter.

1 200-gallon galvanized skim milk vat.

1 300-gallon galvanized butter milk vat.

1 300-gallon galvanized water tank.

1 400-gallon milk receiving vat.

1 Twin cream vat (300 gallon, ice box on end).

1 24-bottle Ideal tester.

1 600-pound five beam scale.

1 60-gallon weigh can.

1 Conductor head and 5-ft. trough.
1 Milk strainer.
1 Ideal wash sink, No. 2.
2 No. 1 rotary milk pumps.
1 Whole milk heater.
1 Pasteurizer for skim milk.
1 Ideal skim milk weigher.
1 Noiseless water heater.
1 14 inch iron head mop with one half dozen extra rubbers.
1 250-page milk ledger.
4 dozen weekly milk sheets.
1 Newton computator.
1 dozen Babcock test bottle brushes.
1 Cream acid tester complete.
½ dozen composite test jar brushes.
50 T. T. pint sample test jars.
1 18 inch butter tryer.
1 8-ounce graduate for color.
½ dozen common floating thermometers.
1 Butter packer.
1 Dairy or New York style ladle.
1 Factory ladle.
1 Butter salting scale.
4 16x1 11/16 adjustable drop hangers.
2 1 11/16 shaft collars.
28 feet 1 11/16 inch shafting.
20 feet ¾ inch 4 ply steam hose.
30 feet ¾ inch 3 ply conducting hose.
1 Belt awl.
50 feet cut rawhide lacing.
5 pounds Italian hemp packing.
1 pound each piston and cylinder packing.

Necessary connections in black piping for boiler, engine, pumps, wash sink, pasteurizer, vats, etc. Necessary check globe and angle valves (Jenkins) for above.

⅓ Dozen extra seats for all valves used.

Necessary ells, tees, unions, nipples, reducers, couplings,

plugs, etc., for above.

1 Main drive wood split pulley.
2 Wood split pulleys for rotary pumps.
1 Wood split pulley for churn.
1 Separator wood split pulley.
1 Pulley (wood split) for starter can.
(Size of pulley will depend upon speed of engine).
2 14-quart pails.
1 Starter can.
½ Dozen gallon butter color.
½ Dozen scrub brushes.
½ Dozen ox fibre brushes.
⅛ Dozen A. B. C. brushes.
3 Gallons sulphuric acid (commercial).
2 Boxes preservative tablets.
1 S. H. dipper (gallon).
1 S. H. dipper (1-2 gallon).
1 Barrel butter salt.
1 Butter maker's set of tools (including saw, hammer, brace, and set bits, wrenches, dies, etc.)
½ dozen extra separator ropes.
1 Elbow strainer for churn.
1 Butter printer.
3000 Parchment wrappers.
100 K. D. 54-pound shipping boxes.
1 Keg floor powder.
1 Spring belt punch.
10 pounds waste.
5 Gallons engine oil.
5 Gallons cylinder oil.
5 Gallons separator oil.
1 Refrigerator, 8x12 feet.
2 Radiators for make room.

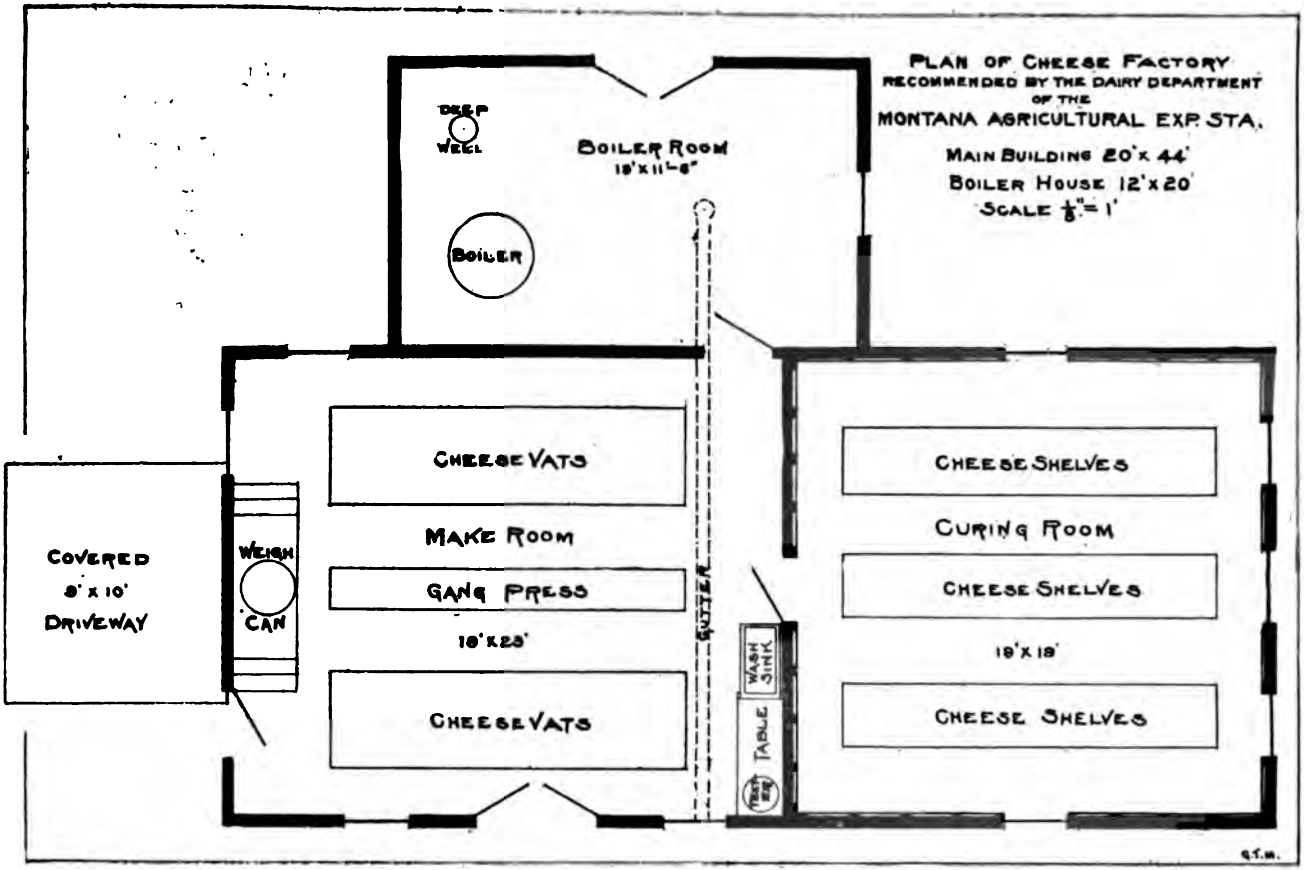
Now in a number of cases we have not specified just exactly the particular make to get, for in such cases there are a number of standard varieties that are equally good. Should anyone desire particular advice on any particular make of machinery, we will be

pleased to help if they write us at the Dairy Department of the Agricultural Experiment Station.

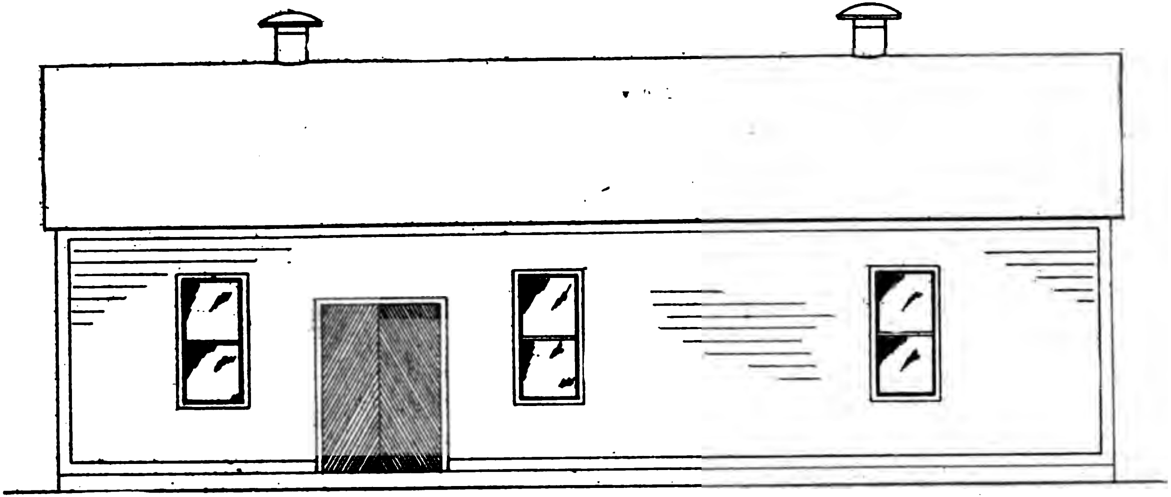
Considerable money can be saved by the farmers getting together and deciding how many milk cans they will need, and also the sizes they want, and ordering them to come in the car of machinery. By this means they can be obtained practically freight free as the freight on the car of machinery will be a fixed rate anyway.

COST OF MACHINERY.

The machinery listed above can be laid down anywhere in Montana for $2300.00, and it will cost in the neighborhood of $200 for local drayage, installing the machinery and doing the necessary piping. So that $2500.00 is ample to pay for a complete list of machinery, including the freight and the cost of installing it. Thus the plant complete will cost for building $2000.00, and for machinery $2500.00. Making the total cost of a 500 to 1000 cow capacity creamery $4500.00.

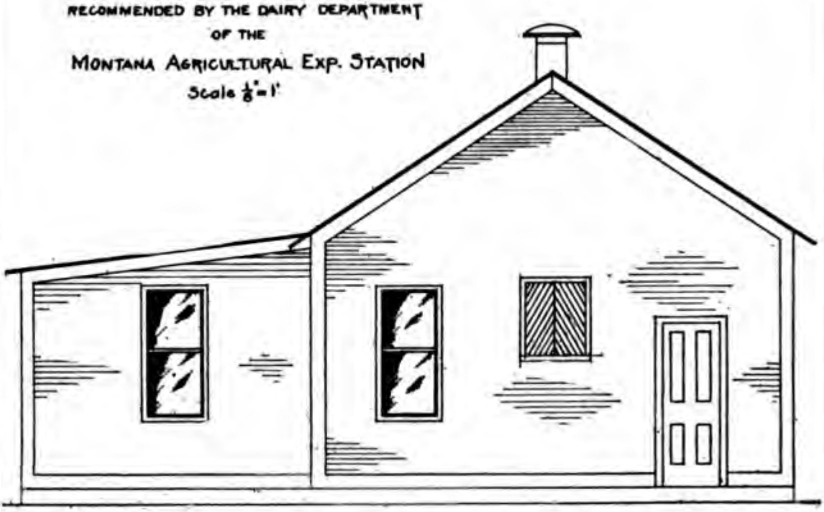

PLAN OF CHEESE FACTORY
RECOMMENDED BY THE DAIRY DEPARTMENT
OF THE
MONTANA AGRICULTURAL EXP. STA.
MAIN BUILDING 20'x 44'
BOILER HOUSE 12'x 20'
SCALE 1/8" = 1'
BOILER ROOM
19'x 11'-6"
DEEP WELL
BOILER
COVERED
8'x 10'
DRIVEWAY
WEIGH CAN
CHEESE VATS
MAKE ROOM
GANG PRESS
18'x 23'
CHEESE VATS
GUTTER
WASH SINK
TABLE
TESTER
CHEESE SHELVES
CURING ROOM
CHEESE SHELVES
19'x 19'
CHEESE SHELVES
G.T.M.

PLANS FOR CHEESE FACTORY
RECOMMENDED BY THE DAIRY DEPARTMENT
OF THE
MONTANA AGRICULTURAL EXPERIMENT STATION
SCALE ¼" = 1'

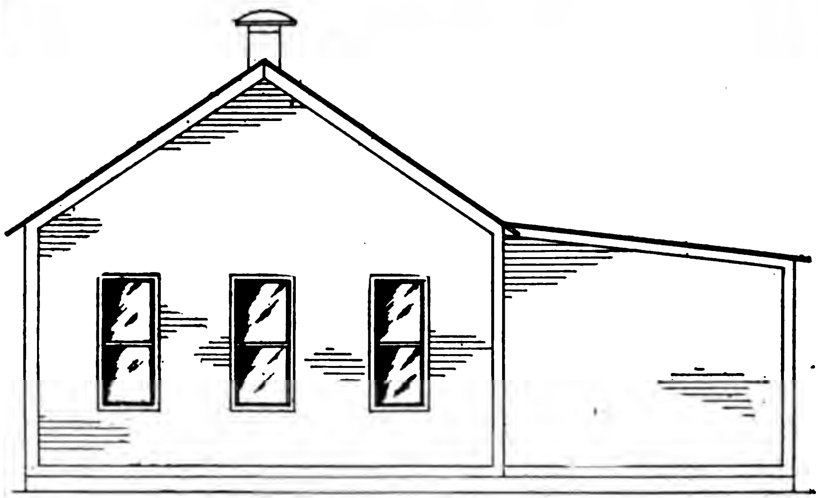


FRONT ELEVATION

PLANS FOR CHEESE FACTORY
RECOMMENDED BY THE DAIRY DEPARTMENT
OF THE
MONTANA AGRICULTURAL EXP. STATION
Scale $\frac{1}{8}$"=1'



RECEIVING-END ELEVATION



END ELEVATION

CHEESE FACTORY.

The same may be said of the requirements and location of a cheese factory as was said of a creamery, with the exception that it does not require as many cows for the successful operation of a cheese factory as for a creamery. A very successful cheese factory can be run with 150 to 200 cows, and such a plant will pay just as well, and possibly a little better, than a creamery with 300 cows at the present prices of cheese. With the same number of cows and at the prevailing prices there is more money in making cheese, by 20 cents per hundred of milk, than by making butter, but the patron has to wait a little longer for his money as cheese has to lie on the shelves from four to six weeks before it is ready for market.

Herewith are given plans of an up-to-date cheese factory.

SPECIFICATIONS.

The main building shall be 20 ft. 44ft., 10 ft. ceiling and 1/3 pitch roof with a boiler room on the side 12 ft. x 20 ft.

1. *Trenches*. Same as trenches under specifications for creamery, page 75.

2. *Stone Work*. Same as under creamery specifications, page 75.

3. *Cement Work*. Only the boiler room will have concrete floor, Cement work to be made and laid as under creamery specifications, page 75.

4. *Carpenter Work*. Same as under creamery specifications, page 75.

5. *Sheeting*. Cover all outside walls as well as roof with 1 inch surfaced sheeting well nailed to every bearing, also walls and ceiling of curing room with same material. On inside, except curing room, ceil up with No. 2 1x6 M. & D.

6. *Window Frames*. All windows to contain two lights 24 inch x 30 inch. All the rest same as under "Window Frames," creamery specifications, page 76.

7. *Roof* of main building and boiler room to be covered with 26

guage metal roofing.

8. *Paper.* Under all roofing and siding cover all sheeting with red rosin sized building paper well lapped and brought up carefully to cornice and frames. In addition the inside walls and ceiling of curing room to be covered on top of 1 inch sheeting with same paper nailed on with 1 inch x 2 inch strips, 16 inch centers. On top of these strips put 2 perpendicular layers of same kind of building paper and ceil up with 1 inch x 6 inch M. & D., thus making two dead air spaces.

9. *Outside Finish*, same as creamery specifications, page 76.

10. *Ventilators*, same as creamery specifications, page 76.

11. *Flooring*, 1x4 vertical grain Oregon fir over all except boiler room. There will be a gutter running across the make room to which the floor from both sides will slope.

12. *Inside Finish.* Same as creamery specifications, page 76.

Doors. All doors same as creamery specifications, page 76.

13. *Sash.* Same as creamery specifications, page 76.

14. *Platforms.* There will be one platform in the make room to hold the weigh scales and weigh can to carry 800 pounds. Platform to be 4 ft. x 8 ft and 3 ft. above the floor. Steps rising to it to have 7¼ inch raise and 9 inch tread.

Where necessary there will be a platform outside of boiler room to hold cans while the patrons are loading up the whey. Platform to be the same size as the one inside.

MACHINERY FOR CHEESE FACTORY.

1 8-H. P. upright boiler complete with fixtures as follows: stack, grate bars, pop valve, steam guage and syphon, water column, with glass water guage, 3 guage cocks, feed, check, and blow-off valves, injector fitted to boiler, whistle, guy wires, flue cleaner, poker, coal scoops, etc.

1 Steam well pump.

Necessary iron pipe for all piping inside factory.

Necessary ells, tees, unions, nipples, reducers, couplings, plugs, etc., for above.

Necessary valves for above fittings (Jenkins).

1 600-pound 5 beam Fairbank scales.
1 240-pound S. B. scale (Family).
1 80-gallon weigh can.
1 Conductor head.
6 Foot conductor trough.
1 500-gallon cheese vat (2 inch gate).
2 Curd racks.
1 Combination Cheddar and Y. A. cheese press.
1 Harris curd mill.
12 14½ inch seamless hoops.
6 Y. A. seamless hoops.
1 24-bottle Facile tester.
1 15-barrel steel tank.
1 Curd pail.
1 14-quart pail.
½ dozen floor scrub brushes.
3 Jorsey brushes.
500 yards 14½ cheese bandage.
500 yards Y. A. cheese bandage.
4 Gallons Hansen rennet.
1 Gallon cheese color.
1 Gallon acid.
1 Box cor. sub. tablets.
1 Allens pay roll.
1 S. and S. record.
1 Dozen rec. sheets.
2 Dozen pint T. T. bottles.
1 17-barrel steel tank.
1 8x20 Hor. curd knife.
1 14x20 Perp. curd knife.
1 L. H. Dipper (½ gallon).
1 S. H. Dipper (1 gallon).
1 Whey strainer for cheese vat.
1 Curd scoop.
1 16-ounce graduate.
1 Stirring knife.
1 Gram measure.

1 Cheese knife for hoop.
1 Dating stencil, paste and brush.
1 Floor mop 14 inch with ½ dozen extra rubbers.
6 Floating thermometers.
1 Barrel cheese salt.
1 4x8 Moore pump.
1 Wash sink, galvanized.
1 Noiseless heater.
1 Dozen brushes.
1 M. 13 1-2 cloth circles.
1 M. 6 1-2 cloth circles.

TOTAL COST OF CHEESE FACTORY.

The same prices have been figured on lumber for the cheese factory as for the creamery. Such a building constructed as per plans and specifications here given can be built for $1500.

A complete outfit of the very best cheese factory machinery, for such a plant, can be laid down in Montana, and placed in shape in the factory ready to run for $800. This price includes actual cost of machinery, freight from Minneapolis or St. Paul to Montana, and the cost of installing said machinery in factory. Thus the factory complete can be built for $2300. This price may vary $100 one way or the other according to the local price of material.

These plans and specifications are given with the hope that they may be of use to those who are thinking of building, and if any one is desirous of using these plans, blue prints may be had by applying to the Dairy Department of the Experiment Station, Bozeman, Montana.

As far as possible, any other help towards the building and equipping of either plant will be cheerfully given.

Montana Agricultural College
Experiment Station

F. B. LINFIELD, Director

BULLETIN NO. 54

THE ALKALI SOILS OF MONTANA

BY

F. W. TRAPHAGEN

BOZEMAN, MONTANA
OCTOBER, 1904

MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

BOZEMAN, MONTANA

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THE ALKALI SOILS OF MONTANA.

SECOND BULLETIN.

In presenting the results of Alkali soil examination of the past few years, it has been deemed advisable to repeat some of the observations and conclusions of Bulletin No. 18, the edition of which is completely exhausted. To this end the following resume of work done in Montana and elsewhere is offered as an introduction to the detailed discussion of the soils of the particular localities investigated.

ORIGIN OF ALKALI.

By alkali soils is meant such soils as contain an excess of soluble mineral salts. Two kinds of such soils are known and are called respectively "Black Alkali" and "White Alkali." The so-called alkali soils are found only in arid or semi-arid districts. In the formation of soils, rocks are disintegrated by the various weathering agents, the most easily decomposed constituents of the rocks being resolved into a soluble component and an insoluble residue. The particular constituent attacked is usually in sufficient quantity to act as a cement to the other constituent minerals of the rock, thus holding them together. By the solution of a considerable portion of this cementing material the remainder is left in such a slightly coherent condition that it is no longer capable of holding the rock together; it thus falls into a loose pulverulent mass the particles of which are of a greater or less size depending upon the size of the original particles. This mass constitutes the original soil which, after being acted upon by the lower forms of vegetable life, ultimately becomes capable of supporting the ordinary crops of the farm.

Now the question of whether or not we shall have an alkali soil after the rock has become disintegrated depends upon the subsequent history of the soluble portion of the original rock. If the climate is humid we have an excess of water to carry away, in solution, soluble salts as fast as formed and ultimately to deposit these salts in the ocean. If, on the other hand, there is scant rainfall, as in arid climates, and the run-off, i. e., the water falling on the surface and passing off without being absorbed by the

soil, is so slight that but a small portion of the soluble salts is removed, these will accumulate to an alarming extent where conditions are favorable to this action.

Let us take a concrete example in illustration of this process. One of the most common rocks is granite which is composed of quartz, mica and feldspar the last being regarded as the cementing material. The quartz is composed of silica which is one of the most insoluble substances in nature and is but little influenced by the disintegrating effects of the various agents active in soil formation; mica contains nearly fifty per cent. of silica, the remainder of its weight being chiefly of alumina which is not readily soluble together with small amounts of potash and oxide of iron; the third constituent, feldspar, is composed of silica, alumina and potash and, while it contains more silica than mica, nearly two-thirds of its weight being silica it is much more easily decomposed than the mica and it is because of the partial solution of this mineral that the rock is weakened and falls to pieces. As thus formed the soil consists of particles of quartz sand and flakes of mica distributed through a mass of loose clay resulting from the decomposition of the feldspar, the whole mixture in turn being permeated by a solution of potassium carbonate and potassium silicate. Now, whether these salts or similar ones formed by the various changes constantly taking place remain in the soil or are carried away depends, as already stated, upon the climate.

Black Alkali: This is of alkaline reaction, the alkalinity being due to the presence of sodium carbonate, "sal soda," in greater or less quantity, and is characterized by a blackness of the soil in which it occurs. This blackness of the soil is produced by the deposit of organic matter, dissolved from organic substances by the alkaline solution of the soil, and left behind after evaporation of the water. This condition is particularly noticeable around the edges of evaporating pools, and upon the complete evaporation of such solutions the former bottom is found covered with a slimy black deposit of finely divided material.

Alkali soil of this sort is extremely uncommon in Montana. On the other hand, a very much smaller quantity of the black alkali is injurious to crops than of the white variety. The most common

remedy for black alkali is its conversion into the less harmful white alkali. The researches of Dr. E. W. Hilgard and his associates in California have shown that much above one-tenth per cent. of black alkali in the surface foot of soil is prohibitive to plant growth.

The action of black alkali is a corrosive one, the vegetable matter being dissolved wherever the comparatively strong alkaline solutions come into contact with it. The plants, especially at the point where the stem emerges from the earth, are often affected to such an extent as to be completely eaten through, and as a consequence a crop may be completely prostrated by the "rise of alkali."

By the application of a top dressing of gypsum, (sulphate of calcium,) a chemical change is brought about resulting in the production of two new substances, the black alkali, (sodium carbonate,) being changed into the less harmful white alkali, (sodium sulphate,) and the gypsum being converted into the equally harmless calcium carbonate or limestone.

White Alkali: This is entirely non-corrosive in its action on vegetable matter, and as already mentioned, is not nearly so harmful in effect as the same amount of black alkali would be. White alkali is composed principally of soluble sulphates, chiefly of sodium and magnesium the former making up the greater part of the mixture; more or less calcium sulphate is also present and these three salts comprise the bulk of nearly all white alkalis, the remainder of the salts being composed of very small quantities of the usual soil-water constituents. Whether the alkali is "black" or "white," depends not only upon the question of its origin but also upon the subsequent reactions of the constituent salts. Thus while it is very unlikely that white alkali would be changed into black yet it very frequently happens that, either by accident or design, the black alkali is changed into the less harmful white through the reaction already discussed.

RISE OF ALKALI.

So long as the salts are distributed through the soil uniformly and do not reach too high a percentage in the surface foot no harm results to vegetation; but, with the advent of irrigation, many sections previously giving no indications of alkali begin to show its presence.

The processes which bring these soluble salts to the surface

are exceedingly simple and easily understood. As is well known, water is Nature's great solvent, and in its course downward into the soil after a rainfall or after the much heavier irrigation, it takes up all soluble matters with which it comes into contact; it thus soon comes to be heavily charged with various salts. These salts, being very soluble, can only be separated from the water in either of two ways; in one the salts would be changed into insoluble compounds when separation could be easily effected. This conversion into insoluble salts is very unusual and extremely unlikely to occur in nature, though it is not an uncommon thing in the chemical laboratory. This leaves the separation of the water and salts to be brought about, if at all, by the other method. This, unfortunately for agriculture in irrigated regions, is only too easily effected. This method is the evaporation of the water from the salt, the latter being left behind on or near the surface of the soil.

In its downward course through the soil water will take up soluble matters until it becomes saturated with them so that it may hold any quantity of salts up to its point of saturation. When the application of water through irrigation temporarily ceases, the direction of the water flow is reversed, and instead of passing from the soil surface downward, it now comes from below to the surface bringing with it its full complement of dissolved materials.

This upward movement is due to the capillary action of the soil and it is a fact that some soils have a capillary power sufficient to enable them to lift water to the surface from a depth of eight feet or more. As this salt-charged water reaches the surface it comes under the influence of the sun's rays and is more or less rapidly evaporated. In this process, however, only the water passes off, the salts remaining behind in exactly the place where they can do the most damage to vegetation. A fresh application of water may be accompanied by a partial carrying down of some of the soluble surface salts but, on the return of this water to the surface through the processes enumerated, it carries with it, not only what it took down, but also an additional quantity of deleterious matter which is thus brought within the danger limits. With the continuation of this process sooner or later a condition is reached prohibitive to vegetable growth.

Another cause of the rise of alkali, more serious in its effects because accompanied by another objectionable feature, is the rise

of the ground water due to excessive irrigation. Charts of underground conditions designed primarily to show the depth to ground water, or permanent water level, show that with the progress of irrigation this water-table—as it is sometimes called—approaches nearer and nearer to the surface until in many cases it becomes actually coincident with the surface. This not only brings about a concentration of mineral salts at the surface, but, because of the ill effect of excess of water upon certain crops, notably alfalfa, would bring about an extermination of the crop even if unaccompanied by an excess of alkali. It is a well-known fact that alfalfa cannot exist with its roots surrounded by a soil saturated with water, and often in alkali districts I have been compelled to attribute the killing out of alfalfa to excess of water rather than to excess of alkăli.

This condition of excess of alkali accompanying a rise of the ground water can be brought about by over-irrigation at the point where the trouble develops or may result from over-irrigation on the part of one's neighbors occupying higher land or by means of leaking ditches at higher points than the affected lands. The two latter causes bring about more serious conditions than do exist when both cause and effect are purely local for the water not only comes to the surface under a greater or less hydrostatic pressure but passing through a much greater area of alkali-containing soil has an opportunity of taking up correspondingly greater quantities of alkali salts ultimately to deposit on the surface.

REMEDIES.

In the light of what has already been said, the discussion of the remedy for the "rise of alkali" can now be intelligently considered. It is evident that these remedies may be considered under three heads, namely: Prevention, Amelioration, and Eradication.

Prevention: This resolves itself into two parts: first, avoding to as great an extent as possible, the solution of objectionable matters and, second, reducing surface evaporation to a minimum.

The first of these results can be attained only by limiting the use of water to the actual needs of the crop and by avoiding a too deep and too great saturation of the soil. This involves also a control of seepage from higher points to prevent rise of the

ground water through leakage of ditches or over-irrigation on the part of neighbors located on higher ground. It is plainly apparent that the trouble we are aiming to avoid, being due to the carrying up of salts from below, can also be prevented if we can carry off the dissolved salts below. This can be done by under-drainage which will be more fully discussed under the third section.

Amelioration: When the salts reach such a percentage in the upper portion of the soil that their ill-effects begin to be apparent, it becomes necessary to reduce their quantity below the danger limit or to plant some crop of greater alkali-resistant power. Such crops, if they, like alfalfa or sugar-beets, either through their foliage or through their culture, assist in reducing the rate of evaporation, are great aids. In addition to this I have found that the alfalfa from alkali districts has a much greater percentage of ash, principally alkali salts, than that from non-alkali sections, hence the alkali would be constantly removed with the crop ultimately leaving the soil in a condition fit to support any crop. Sugar beets also have been found to take enormous quantities of alkali salts from the soil but, unfortunately, such beets are not suitable for the manufacture of sugar.

Ploughing in of manure, straw or similar material, especially as soon after an irrigation as it is possible to work the ground, will be found useful for two reasons: first, the admixture of this material with the soil proportionately reduces the percentage of alkali: and, second, it reduces the rate of evaporation, especially if more of this material is applied loosely over the surface.

It must be understood that the success of this treatment is due not to any chemical reaction but solely to the reduction of the relative amount of alkali on the surface of the soil, and further to the reduced rate of evaporation brought about by the changed texture of the surface soil.

The reason for applying this mulch as soon as possible after the use of water is that the surface alkali is temporarily carried down into the soil as previously explained and much of it may thus under proper treatment be kept out of the danger zone.

By judicious surface flooding of the land the amount of alkali in the surface portions may be temporarily reduced. This method requires great care or the conditions will be made worse instead of better. Two conditions for the successful application of this

process are imperative, namely: plenty of water and a suitable slope to make possible the immediate removal of the salt-saturated water. This scheme of treatment may be successfully followed to bring about the removal of the greater part of the surface crust of alkali so commonly seen in badly affected alkali districts, but it must only be considered as a temporary expedient and not as a final remedy. The same thing may be said of the other methods of treatment so far discussed.

Eradication: This can only be brought about in one way —by under-drainage. When there is an efficient natural under-drainage there is no alkali. This of itself should give us confidence in the efficacy of the method under discussion.

Artificial under-darinage is, of course, very expensive and it has been a question whether, with the comparatively cheap lands of the west, under-drainage was economically advisable; whether, in other words, it was wise to put as much, or more, than the rated acre-value of the land, into a system of under-ground tiling for the purpose of drainage.

It seems to me that the question is rather:—Have we put a proper valuation on our farm lands? Are lands which produce five tons or more of alfalfa per acre worth only the low price current? In eastern farming districts the yield per acre rarely nets as much as the irrigated lands of Montana, for instance of the Yellowstone valley. Yet when the necessity for under-drainage is apparent in the east a system is at once installed. If the basis for the valuation of land is its annual yield per acre, is the land properly appraised? If more highly appraised land in the east yeilding no larger crops can be economically under-drained why can ours not be treated the same way?

Under-drainage, let it be well understood, is not a provisional remedy but a final one. Land so treated soon comes up to its maximum efficiency and can be so maintained with proper handling. A year or two before land becomes barren, through rise of the alkali, almost phenomenal crops are raised. This is because the alkali is not a poison but a plant food when present in properly limited quantities: it is even a necessity; it is the life of the plant. It is only when it is in excess that trouble ensues. Even the most necessary and most important plant food would prove deleterious and even prevent plant growth if present in too great a quantity.

Under-drainage makes possible a control of the quantity of salts in the soil. Over-irrigation in a properly drained field will now produce no ill results except that attendant upon a perversion of the water from a possibly more useful channel. On the other hand, excessive use of water is followed by a corresponding carrying off of dissolved salts downward through the avenues provided for the escape of this water, so that, instead of the excess of water bringing to the surface great quantities of mineral salts to kill plant life, it actually carries away these salts soon leaving the soil in ideal condition. Here too, however, there is danger of carrying this process too far for an excess of mineral salts is distinctly harmful. On the other hand, small quantities are absolutely necessary and extreme care should be exercised to prevent loss of these very important plant foods which are available only when in a soluble form in which form also they are most likely to be carried off.

In irrigation, then, the farmer has a two-edged sword which must be wielded with the greatest care; properly handled, the best results are obtained: improperly handled, ruin is almost sure to follow.

Another advantage possessed by proper under-drainage is the protection it affords its owner against damage through seepage from higher lands or ditches, for with this system in use the ground water is limited in its rise by the drain tiles.

Under-drainage is the remedy for the "rise of alkali" and should be adopted wherever possible.

As a concrete example of what can be done by use of the system herein advocated, the following resume of actual results accomplished by Messrs. Means and Heilman of the United States Department of Agriculture is offered in evidence:

"Reclamation of Alkali Land at Fresno, California."

"At the time of settlement of the country south of Fresno there was a little indication of the presence of alkali in the soil and no one then suspected that serious damage would result from irrigation. When, after a few years, alkali commenced to show in the vineyards and orchards the attention of thoughtful men was directed toward remedying the evil but up to the time of undertaking the experiment herein reported nothing effective had been accomplished.

"In 1900 a party from the Bureau of Soils spent a season in

studying the soil conditions around Fresno, and in a paper embodied in the report on field operations of the Division of Soils for 1900 recommended drainage with frequent cultivation and copious irrigation during reclamation, as the solution of the alkali problem.

"Notwithstanding the recommendations in this report and the repeated statements in subsequent reports on alkaline areas in different parts of the country that drainage is a practicable and the only safe and sure means of permanently reclaiming alkali lands, no steps had been taken by persons most deeply interested to check or remove the evil. The Bureau of Soils, after careful consideration, decided that the most convincing way of bringing the truth of its recommendations and the value of drainage in reclamation work before the people was to demonstrate it by actual reclamation of some of the alkali land. For this purpose the Bureau selected a 20 acre tract of land belonging to S. M. Toft and N. H. Hansen situated on Fig and Central avenues about 2½ miles south of Fresno and entered into cooperation with these gentlemen to demonstrate to the people of the irrigated region that alkali lands can be easily and economically reclaimed.

"The history of this land, as given by the owners, is as follows: The northern part of the tract was settled upon by Mr. Toft in 1876 and at that time showed no signs of alkali. The southern part of the tract was first settled upon in 1862 by Mr. Hansen and at that time was partially alkaline. It has never produced good crops. In 1890 alkali commenced to show on the northern part and in 1898 and 1899 it was practically abandoned.

"The tract lies in a level district where it is impossible to obtain a gravity outlet for the drainage water except by digging a drain 2 miles long, so in order to raise the drainage water to the surface of the ground, a chain pump operated by a water wheel was installed on Central Canal where it crosses Fig avenue. A drainage system of this kind is admittedly not so desirable as one in which a gravity outlet can be maintained.

"Three-inch, 4-inch and 6-inch tile were laid over the tract at an average depth of a little over 3 feet and 150 feet apart. The original intention was to use nothing smaller than 4-inch tile but the makers were unable to supply enough of this size so the deficiency was made up by using 3-inch tile. It was found impossible to lay the tile during the summer season, owing to the nearness

of the water table to the surface and the resulting condition of the subsoil which was too soft to permit the digging of a deep ditch. The work of ditching was commenced in December, 1902, and was completed in February, 1903. The cost of ditching, tiling, and all incidentals except the cost of pump and water wheel amounted to $16.50 per acre. The contract for the tile delivered in Fresno was for 3-inch tile, $24 per thousand, for 4-inch tile,$32 per thousand, and for 6-inch tile, $72 per thousand.

"At the time of the installation of the drains 18 acres of the land contained too much alkali to produce a crop. Scattered over a part of the tract were small patches of alfalfa and an occasional fruit tree—remnants of former cultivation. About the 1st of March 1903, irrigation was commenced. The land was divided into 30 checks the size of each check depending upon the slope of the land. The largest checks, those on the level land, are about 2 acres in extent, while on the steeper slopes they are less than half an acre. The object was to divide the land in such a way that it could all be kept under water to a depth of 4 inches, and the reclamation was to be accomplished by maintaining the water at this depth until enough alkali had been washed out of the soil through the drains to enable a crop to be grown.

"During the progress of flooding many difficulties were met, among them that of keeping the tiles from partially filling with sand and silt. Precaution was taken in laying the tile to put them in so that the joints would be close. Hay was thrown over the tile in the ditch before covering with earth and a ridge of earth was thrown up to prevent the water from standing directly over the drains. In spite of these precautions the soil, which is very light, was so easily moved by water that it seemed to enter the joints almost as readily as the water. This resulted in some of the drains becoming clogged and it was necessary to relay a portion of the tile. After the land had been once thoroughly soaked and had settled, no difficulty was experienced from filling of the drains and it is to be hoped that there will be no further trouble from this source. Most of the trouble was with the 3-inch tile which is admittedly too small for use in soils of the light and silty character of the Toft-Hansen field. It is thought that there will be more or less silting up of the tiles whenever they are used in the sandy and white ash soils of the Fresno district and it was recommended

that every possible precaution be taken in putting them in. Much of the trouble may be obviated by using no tile smaller than 4-inches, or preferably 6 inches in diameter, and by giving the laterals such fall that the velocity of the water will be great enough to wash out the sand as rapidly as it enters the joints. The tiles on the Toft-Hansen tract have a fall of 1 in 1,000 and the velocity of the water flowing through them is not sufficient to remove the sand. With a fall of 1 in 500 the velocity is great enough to remove practically all of the soil as fast as it enters.

"To prevent entirely the clogging of the tile with sand and to insure the removal of roots should any chance to enter, it is thought advisable to place in all tiles a quarter inch galvanized strand-wire rope. Then two or three times a year, or oftener if necessary, a wire brush should be dragged through the tile in order to cut out all roots and stir up the sand and silt. Wire rope of this kind can be bought for about 1 cent a foot. Six-inch and 8-inch drains have been in operation for twelve years in the Sunnyside vineyard and have been kept in perfect condition in this way. From the experience gained the Bureau can unhesitatingly recommend tile for drainage purposes provided proper precautions are taken in its installation.

"On July 15, 1903, after four and a half months of irrigation, an examination was made of the tract to determine what percentage of the land was sufficiently sweetened to grow a crop. This examination indicated that all of the land, with the exception of small spots amounting in the aggregate to less than 2 acres, was then ready for a crop. Most of it was sufficiently freed from alkali to warrant the sowing of alfalfa but as midsummer is not the best time of the year for seeding that crop, sorghum and Egyptian clover were put in instead. These crops will mature by fall if the supply of irrigation water does not fail, and in the winter the land will be seeded to alfalfa. The small spots which are not yet ready for alfalfa are rapidly approaching that condition and will be ready for a crop during the coming winter. Thus it will be seen that practically all the land in this 20-acre tract has been returned to a state of profitable cultivation in a period of four and a half months after irrigation was commenced, and the statement seems justified that any alkali land in the Fresno district can be brought into profitable cultivation in less than one year's time the two requisites for this

being under-drainage and a copious supply of water for irrigation. While the Bureau considers the land of the Toft-Hansen field practically reclaimed at the present time the demonstration will be continued until a satisfactory stand of alfalfa is secured."

EXPERIMENTS TO DETERMINE THE EFFECTS OF ALKALI.

An inspection of the plates will show plainer than words the results of these experiments. In explanation it may be said that the soil used was the best soil of the Montana Experiment Station farm. Where the word "blank" is used, it indicates that the soil alone was present, while in each of the other pots, the soil had added to it an amount of alkali, in percentage of its own weight, as designated.

The presence of magnesium sulphate—epsom salt—in quantity up to one per cent has apparently no ill effect upon the growth of alfalfa.

The limiting quantity of sodium sulphate—Glaubers' salt—for alfalfa seems to be about seven-tenths of one per cent.

With a mixture of two-thirds sodium sulphate and one-third magnesium sulphate, which in these experiments is termed "mixture", and which represents very closely the composition of Montana alkali, the limiting quantity appears to be about the same as with sodium sulphate alone.

It should be said that these experiments were conducted with great care, the purpose being to eliminate every adverse condition except that imposed by the presence of the "alkali". Especially was it provided that a sufficient quantity of water should always be present..

In this connection it may be stated that the presence of alkali was observed, in another series of experiments, to very materially increase the draught-resistant powers of the plants under investigation.

Plates IV and V. illustrating the results of experiments with oats, wheat, barley and timothy, tend to show that the danger limit for alkali of the character of that found in Montana, is above one per cent.

DISCUSSION OF TABLES.

In the tables of analyses accompanying this bulletin are given the results of the work done in various parts of the State since the publication of Bulletin No. 18.

Samples were taken with a soil auger making a one and three-quarter inch hole, the auger bit being welded into a section of quarter inch gas pipe, attached to a proper handle. Additional sections, each three feet long, were easily added to the auger. With this instrument it was possible, except in rare cases, to take samples to a depth of eighteen feet or more. These samples were sacked and labeled in the field and forwarded to the chemical laboratory for analysis.

The results of analysis are stated in terms of chlorine, sodium sulphate and sodium carbonate.

Complete analyses of the soils were made only on rare occasions when some particular object demanded this additional work.

The chlorine proved to be very constant in amount in the various soils and it was concluded that there was no particular importance to be attached to its presence.

The alkalinity of the soil was attributed to sodium carbonate and calculated as such, even though it was conceded that the bi-carbonate might have caused the alkalinity especially at some depth. The point of importance, however, and that to be kept in mind, is that when the bi-carbonate reaches the surface it quickly changes into the harmful carbonate, hence the presence of the bi-carbonate in the soil water is a constant menace.

As has been previously stated, the question of the presence of carbonate in the soils of Montana has not except in one or two instances, proven to be of a serious one because of its small quantity.

It is to the sodium sulphate that we are to look for the cause of the injurious effects to our crop in alkali regions in our state. In the column giving the percentage of sodium sulphate present are given not sodium sulphate alone, but the equivalent in sodium sulphate of all the other sulphates present. This is done because repeated analyses from different sections showed that sulphate was the predominant salt of Montana alkali.

Comments are made on a number of samples to serve as a

basis for the treatment of any particular soil in which the reader is interested.

Samples Nos. 1069 to 1072, inclusive, from Alex. Proffit, Manhattan.

These show a remarkable condition to exist, namely, a good growth of grass, mainly blue stem, where the percentage of alkali is so great as to be deemed fatal to any crop. Nearly two and a half per cent in the surface foot, with one per cent in the second foot would be considered by many to be absolutely fatal to plant life, but here we have the facts.

No. 1073.—From same field as above: Grass very much poorer, no sign of alkali on the surface, and only twenty-eight thousandths of one per cent. sodium sulphate in the surface foot. Evidently some other reason than the presence of alkali must be sought to explain the anomalous condition. Is it that even though on lower ground than the previous plat, and yet dry, that there was a sufficient difference in its texture to account for its dry condition, while the other sample was moist? These examples show how many sided is the problem before us, and how dangerous it is to lay down any definite rules until the whole ground has been carefully studied from every possible point of view.

No. 1074. Ditch east of the College.

This example is cited principally to show how much salt may be present in the soil and yet not reach the surface. Over one-half per cent is present in this soil, yet there is no indication at the surface of its presence. The land has never been irrigated but even if it had been the drainage is so perfect that no accumulation of alkali would take place. ,

Nos. 1075 to 1097 inclusive, from the Chas. M. Bair ranch, Canyon Creek, Yellowstone County.

This soil shows the presence of a relatively small amount of alkali down to a depth of seven and one-half feet, so little in fact that were it all concentrated in the surface foot it would only amount to three-tenths of one per cent, too little to harm crops. From this point downward an equal distance, is found a very striking concentration of salts, and so great is the quantity, that if all the salts in the second ninety inches were collected in a single foot it would amount to over six per cent, or more than twenty times as much as is present in the upper ninety inches. Evidently any process of irrigation in which care is taken to avoid a deep penetration of the water

applied, while at the same time efforts are put forth to prevent a rise of the ground water, will prove successful as long as it attains the two objects aimed at. This ranch ought never to become "alkaline."

Nos. 1098 to 1111 inclusive. Hesper Farm, Yellowstone County.

The samples from the two fields included in this series are chiefly interesting from the fact that the alkali is present in very small amounts even though irrigation has been practiced here for many years and in the face of the fact that very large amounts of alkali are known to be concentrated at depths of ten to eighteen feet in the virgin soil of this section. The apparent immunity of these fields is due to reasons already pointed out.

Nos. 1140 to 1153 inclusive. The P. B. Moss ranch, near Billings.

The samples representing the soil in two portions of the same ranch are chiefly interesting in showing the small quantity of alkali at the surface as compared with that contained at greater depths. In a case of this kind constant attention is needed to prevent the rise of alkali and of ground water. All the elements necessary to cause infinite trouble are here present and it is to be avoided only by continuous effort. As a matter of fact, large portions of lower-lying ground on this ranch are already destroyed by the combined effects of excess of alkali and of moisture.

Nos. 968 to 974. Gird Creek. Bitter Root Stock Farm. Gilchrist ranch.

Here is the nearest approach to black alkali, both in its composition and its effects, that we have found in Montana. It has a distinctly injurious effect upon crops which have been tried upon it.

Nos. 927 to 929. Three Forks.

This is in its composition a typical "black alkali" soil also, but being in a non-cultivated section, its actual effects upon an ordinary crop could not be observed. What this effect would probably be, however, is indicated by the deep colored solution yielded by the soil when leached with water. This color is due to the solvent effect of the alkaline solution upon the humus of the soil and, of course, it would have a like solvent, and consequently damaging effect upon growing vegetation.

Nos. 1713 to 1724. Samples from Poplar, Montana.

These samples are mainly interesting as showing the location of the "Zone of Concentration" of the alkali and as indicating the

course to follow in treatment of the land.

Nos. 1725 to 1744.

These samples were taken from various points in the Milk River Valley many or all of which are involved in the "Milk River Irrigation Project." All samples taken in this region have shown a concentration of salts principally at a depth of from four to six feet. With the advent of a plentiful supply of water the danger of concentrating this alkali at the danger point, that is, in the surface foot, becomes imminent, and we strongly urge the most careful attention to the rules laid down in this bulletin.

As has been previously stated only a few of the analyses made could be discussed in a bulletin of this nature. However, in case of a special interest on the part of any of the readers of this bulletin, in a particular soil, we are willing to answer any question concerning it that may arise.

My thanks are due Mr. Edmund Burke, Assistant Chemist, for invaluable aid in collecting samples, and for the work done in analyzing the greater part of the samples.

CONCLUSION.

The Montana farmer has the control of the alkali question entirely in his own hands, and whether his farm shall be abandoned as worthless, or made to "blossom as the rose" and yield crops of enormous size, rests entirely on his intelligent management.

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PLATE I. Experiments with alfalfa showing the effects of different proportions of magnesium sulphate.

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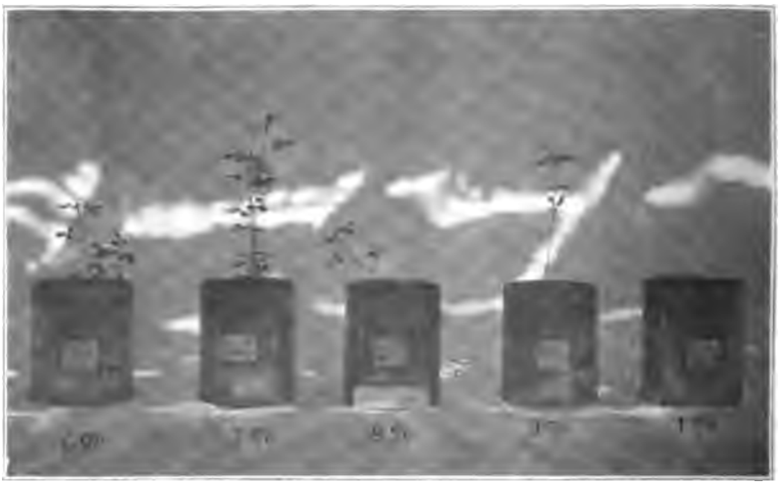

PLATE II. Experiments with alfalfa showing the effects of different proportions of sodium sulphate.

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6

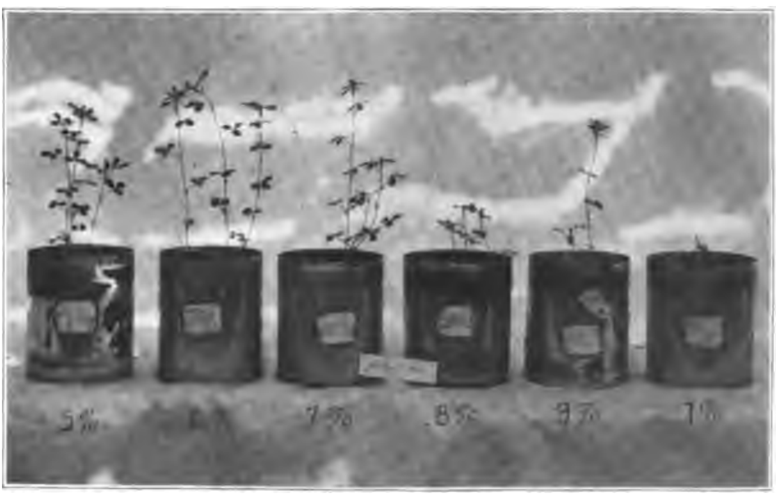

PLATE III. Experiments with alfalfa showing the effects of different proportions of "mixture."

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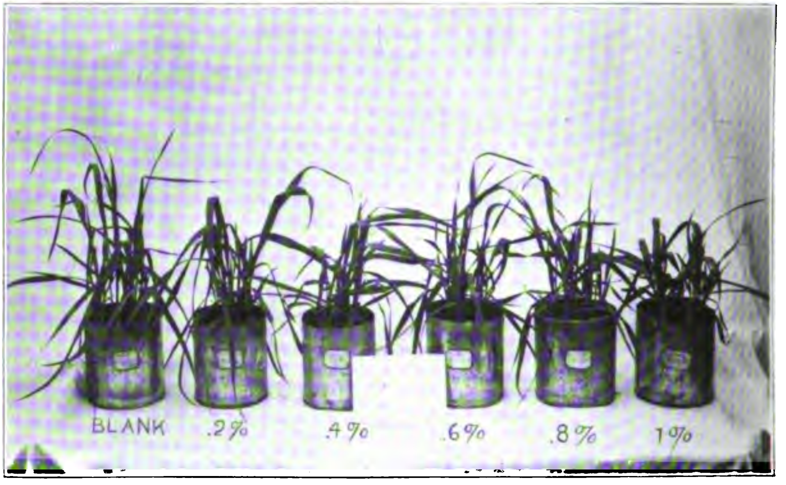

Experiments with oats showing the effects of different proportions of "mixture."

8

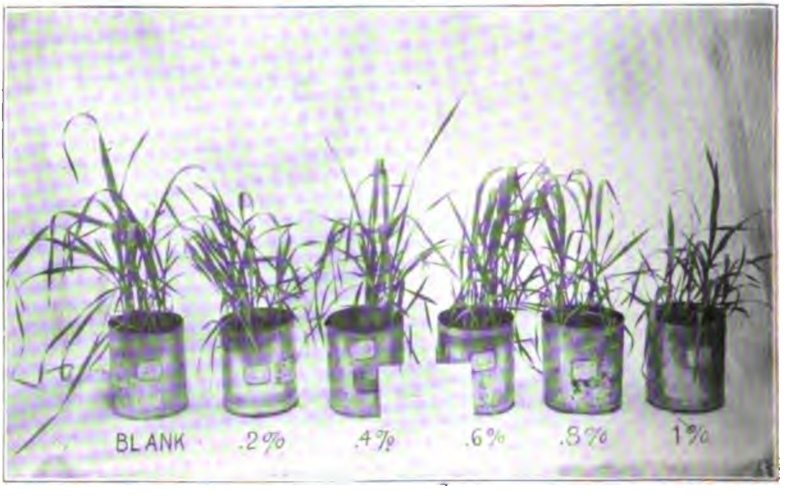

PLATE IV. Experiments with wheat showing the effects of different proportions of "mixture."

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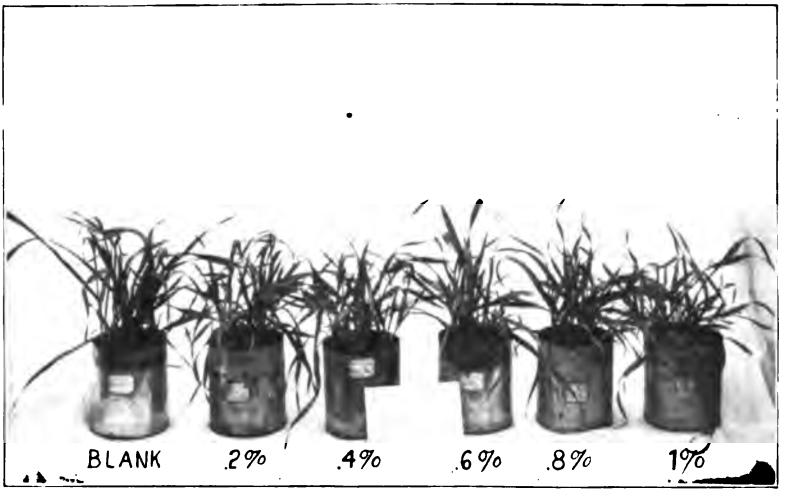

Experiments with barley showing the effects of various proportions of "mixture."

10

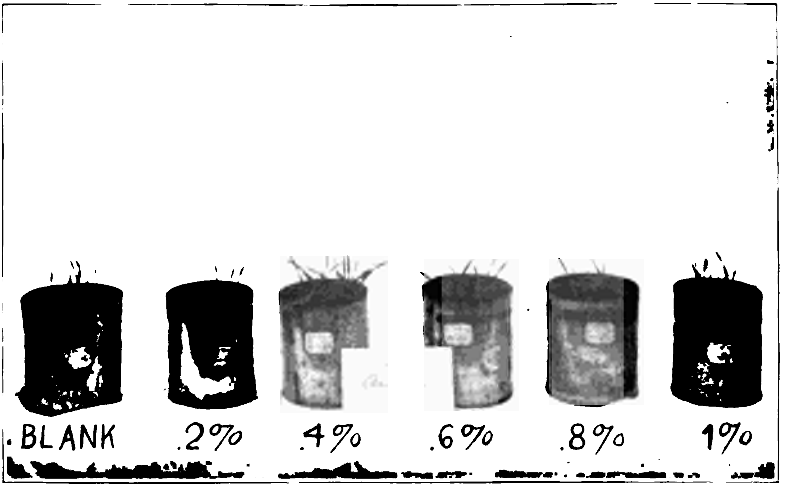

PLATE V. Experiments with timothy showing the effects of different proportions of "mixture."

TABLES OF ANALYSES.

Description	Laboratory Number	Chlorine per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
August 8, 1900.						
Smith River No 1	924		.467	.13	1st foot	
Smith River No. 2.	925		.052	.11	2d foot	
Smith River No. 3	926		.037	.1	3d foot	
Three Forks No. 1	927		.135	.424	1st foot	Yield dark colored solution on treating with water.
Three Forks No. 2	928		.06	.16	2d foot	
Three Forks No. 3	929		.03	.16	3d foot	
John Pickerings ranch near Townsend.	930		.018	.037		
John Bering's bench farm.—Soil.	931		.028	.1		
John Bering's bench farm.—Subsoil.	932	Trace	12.18	.069		Surface alkali.
Gird Creek, Gilchrist ranch, Bitter Root Stock Farm.	968	.0176	.003	.1	1st foot	
	969	.035	.0348	.159	2d foot	
	970	.035	.0186	.1[illegible]	3d foot	
	971	.0176	.0246	.1749	4th foot	
	972	.035	.0234	.1484	5th foot	
	973	.0176	.0174	.0848	6th foot	
	974	.0176	.0048	.09		
Bitter Root Stock Farm, greenhouse orchard.	975	.0176	.0066	.053	1st foot	
	976	.0176	.0024	.053	12-18 in.	Gravel.
	977	.0176	.0294	.0583	1st foot	
	978	.035	.0146	.0795	2d foot	
	979	.0176	.0102	.0848	3d foot	Gravel.
Bitter Root Stock Farm, Lot's place under bench.	980	.0176	.0258	.0477	1st foot	
	981	.0176	.0552	.0689	2d foot	
	982	.035	.0696	.1325	3d foot	
	983	.0176	.0612	.18	4th foot	
	984	.0176	.0528	.34	5th foot	
	985	.0176	.0402	.127	6th foot	Gravel.
	986	.0176	.012	.053		

TABLES OF ANALYSES.

Description	Laboratory Number	Chlorine per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
John L. Humble, north of Corvallis.	987	.0176	.0096	.0424		Loam 4 ft. to sand, 4 ½ gravel.
Fred Wehr, Corvallis.	988	.0088	.006	.037		Fine earth 3¾; rejections 1⅛ oz.
Curlew Mining Co., Orchard, Victor,	989	.0088	.0036	.0265		Granite soil, fine 2 lbs. 13 oz., rejs.. 2 lbs. 8 oz.
W. Parkhurst, Corvallis.	990	.0176	.0048	.0848		Fine soil, sandy to 6 ft. Fine earth 3 lbs. 5 oz, rejs. 2 oz.
Bitter Root Stock Farm—						
30 acre-orchard.	991	.0176	.0120	.0477		Fine earth 3lbs. 10½oz.; rejecs. 10 oz.
Gilchrist orchard; trees dead.	992	.088	.1386	.0742		Fine earth 3 lbs. 6½ oz.; rejecs. 3 oz.
East Orchard, foot hills, 25 acre.	993	.0088	.0060	.0318		Fine earth 3 lbs. 11 oz.; rejs. 14½ oz.
Pendergast.	994	.0088	.0108	.0424		Fine earth 2 lbs. 1½ oz.; rejs. 7½ oz.
Hospital orchard, 10 acres 2000 trees	995	.0088	.0072	.0477		
Sugar-beet field, 60 acre orchard.	996	.0176	.0138	.0477		Fine earth 4 lbs 6 ½ oz rej 6 oz.
100 acre orchard bench.	997	.0176	.0114	.0583		Fine earth 3 lbs. 12 oz. Rejections 8 ½ oz.
September 6, 1899.	1069	.1	2.408	.032	1st foot	Mixed grass meadow mainly blue stem
Alex. Proffitt, near forks of Gallatin,	1070	.05	.992	.0212	2d foot	alkali showing in few places good
about 4 miles north of Manhattan.	1071	.0184	.545	.0583	3d foot	growth. Irrigated in June.
	1072	.0092	.199	.0422	4th foot	
Same field, lower ground, (a sag.)	1073	.0092	.028	.0477	1st foot	Dry. Grass very much poorer. No signs of alkali on surface.
From ditch dug east of College for city water pipes.	1074	.0092	.527	.1113		

Chas. M. Bair ranch at mouth of Canyon creek, Yellowstone Co., ¼ mile east of house, 100 feet from edge of cliff above creek.	1075	.046	.021	.0477	1st foot	Moist. Underdrainage through coarse sand and gravel. No evidence of alkali on surface. Field yielded 8 tons of alfalfa per acre last season, three cuttings. Irrigated two weeks ago, crop cut ten days previous. Soil uniformly moist. Third year of cultivation, 1st year grain, alfalfa following.
	1076	.0092	.008	.0583	12-24 in	
	1077		.013	.053	24-30 in	
	1078		.019	.053	30-36 in	
	1079		.017	.0689	36-42 in	
	1080		.015	.0689	42-48 in	
	1081		.022	.053	48-54 in	
	1082		.11	.053	54-60 in	
	1083	.0276	.023	.047	60-72 in	
	1084		.017	.064	72-84 in	
	1085		.055	.074	84-90 in	
	1086		.722	.027	90-96 in	
	1087		.609	.027	96-102 in	
	1088		.479	.032	102-108 in	
	1089		.470	.027	108-114 in	
	1090	.084	.738	.027	114-120 in	
	1091	.092	.509	.027	120-126 in	
	1092	.092	.473	.027	126-132 in	
	1093	.092	.333	.027	132-144 in	
	1094	.092	.488	.027	144-150 in	
	1095	.092	.538	.021	150-156 in	
	1096		.335	.021	156-168 in	
	1097	.007	.342	.027	168-180 in	
August 31. Hesper farm, Yellowstone Co., grass field near east gate of farm, 100 yards south of road in ranch.	1098	.004	.00	.0636	1st foot	
	1099	.002	.0013	.0742	2d foot	
	1100	.004	.00	.0583	3d foot	
	1101	.003	.012	.053	4th foot	
	1102	.004	.087	.0424	5th foot	
	1103	.003	.040	.0477	6th foot	
Hesper farm, alfalfa field, 200 yards yards north of preceding location.	1104	.004	.014	.0689	1st foot	
	1105	.003	.01	.0689	2d foot	
	1106	.003	.014	.0636	3d foot	
	1107	.002	.101	.053	4th foot	
	1108	.008	.125	.0583	5th foot	
	1109	.004	.142	.053	6th foot	

TABLES OF ANALYSES.

Description	Laboratory Number	Chlorine per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
Blue stem natural meadow under high line ditch.	1110	.004	.012	.069	1st foot	Not yet irrigated.
	1111	.011	.448	.0424	2d foot	Soil too dry and pulverulent to sample to depth.
Billings Estate, section 17, 100 yards southeast of east Hesper farm gate.	1112	.009	.156	.0583	1st foot	Blue stem and sweet clover.
	1113	.006	.114	.069	2d foot	
	1114	.005	.138	.053	3d foot	
	1115	.005	.137	.0583	4th foot	
	1116	.004	.08	.0583	5th foot	
	1117	.004	.082	.0583	6th foot	
Billings Estate, 100 yards northeast of the Hesper farm gate.	1118	.003	.00	.0371	1st foot	Depression in which water has stood and in which grass is very green. At end of 1st foot moist.
	1119	.002	.00	.0583	2d foot	
	1120	.002	.00	.067	3d foot	
	1121	.003	.00	.064	4th foot	
Hesper Farm, blue stem field, 100 yards from lane and 100 yards from east side of farm.	1122	.002	.00	.0583	1st foot	
	1123	.002	.00	.053	2d foot	
	1124	.005	.00	.064	3d foot	
	1125	.002	.008	.053	4th foot	
Hesper Farm Alfalfa field, 100 yards north of lane and 100 yards west of road.	1123	.00	.051	.053	1st foot	
	1127	.002	.168	.059	2d foot	
	1128	.003	.174	.064	3d foot	
	1129	.007	.123	.059	4th foot	
	1130	.004	.207	.059	5th foot	
	1131	.007	.347	.059	6th foot	
100 yards east of Shiloh school house, Yellowstone county.	1132	.055	1.052	.0371	1st foot	Blue stem meadow.
	1134	.035	.767	.053	2d foot	
	1135	.012	.258	.069	2½ ft.	
Efflorescence from above locality.	1133	.736	23.208	.0212		

Description	Laboratory Number	Sodium Chloride per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
Same field, 112 yards south of north line of field. Patch showing surface efflorescence.	1136	.034	.25	.048	1st foot	
	1137	.050	.485	.0583	2d foot	
	1138	.041	.968	.0424	3d foot	
	1139	.036	1.065	.048	4th foot	Water.
P. B. Moss ranch Yellowstone county	1140	.024	.037	.048	1st foot	Lower portion coarse sand.
	1141	.012	.019	.0583	2d foot	
	1142	.007	.014	.0583	3d foot	
	1143	.008	.013	.0583	4th foot	
	1144	.014	.088	.0583	5th foot	
	1145	.017	.096	.0583	6th foot	
	1146	.029	.146	.053	7th foot	
	1147	.016	.252	.048	8th foot	
	1148	.019	.366	.0424	9th foot	
P. B. Moss ranch, Alfalfa field below ditch. Sept. 1, 1900.	1149	.009	.091	.0583	1st foot	Below ditch good growth.
	1150	.005	.433	.053	2d foot	
	1151	.012	.551	.048	3d foot	
	1152	.011	.59	.048	4th foot	
	1153	.011	.453	.053	5th foot	
Efflorescence from sides of Bozeman City water ditch.	1154		12.21			
April 20, 1900. Sunny Side Stock Farm. T. C. Power.	1175	.19	.0567	.18		

Description	Laboratory Number	Sodium Chloride per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
Fort Ellis Reservation—						
Bunch grass meadow	1353	.0016	.015	.0107		General sample.
Oat field west of road.	1354	.013	.023	.0053		General sample.
Fall wheat east of road	1355	.0016	Trace	.0053		General sample.
Spring wheat east of road	1356	.0016	Trace	.01		General sample.
Spring wheat west of road.	1357	.0033	Trace	.01		General sample.

TABLES OF ANALYSES.

Description	Laboratory Number	Chlorine per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
J. W. Strevell, Miles City—						
General sample alfalfa field.	1437	.0356	.0158	.037		
Gumbo soil, near Beck's	1438	.0089	.039	.11		
Sugar beets last year alfalfa this	1439	.0053	.0268	.0477	1st foot	
year.	1440	.0035	.0177	.0424	2d foot	
Alkali spot, very moist slough.	1441	.0017	1.50	.0212	1st foot	
	1442	.0089	.62	.0265	2d foot	
	1443	.0089	.516	.0318	3d foot	
W. B. Jordan, Miles City,—						
General samples cracked surface soil	1444	.0017	.048	.0795		Red Top ranch, subsoiled 2 years ago.
	1445	.0071	.375	.053	3-12 in	Moist.
Dry hard pan from 18-24	1446	.0017	.71	.0477	2d foot	
Dry hard pan from 24—30	1447	.0071	.40	.053	3d foot	
Red Top ranch, grease wood surrounded by bare spot	1448	.0071	.082	.116		
	1449	.0089	.0158	.037		25 feet from No. 1448. Fine growth of alfalfa.
Homer Squyer, Wibaux	1450	.0089	.0115	.037	1st foot	
	1451	.0089	.0146	.053	2d foot	
	1452	.0053	.078	.053	3d foot	
	1453	.0089	.70	.0265	4th foot	
	1454	.0071	.49	.0318	5th foot	
	1455	.0071	.111	.0212	6th foot	
	1456	.0089	.048	.0159	7th foot	
Wm. H. Ellis, Bozeman,—						
80 acre field, summer fallow	1457	.0053		.0106		General sample. Field sowed to timothy and alsike.
Northeast corner near alkali spot	1458	.0089		.0212	1st foot	Summer fallow yield good.
Northeast corner near alkali spot	1459	.0071		.0265	2d foot	

Northeast corner near alkali spot	1460	.0035		.0318	3d foot	
Northeast corner near alkali spot	1461	.0035		.0265	36-42 in	Gravel and water.
Northeast corner near alkali spot	1462	.0025	.051	.0212		General surface sample for alkali.
Alkali spot	1463	.0356	.032	0371	1st foot	
Alkali spot	1464	.0053	1.08	.0265	2d foot	
Alkali spot	1465	.0071	.45	.037	3d foot	2 ½ ft water, 3 ft. to gravel.
W. H. Ellis, Bozeman, Aug. 8, 1900.—						
8 acre field.	1466	.0125		.053	1st foot	
8 acre field.	1467	.024		.011	2d foot	
8 acre field.	1468	.0142		.026	3d foot	
8 acre field.	1469	.0071		.016		General sample.
80 acre field	1470	.0071		.0106	1st foot	General sample.
80 acre field	1471	.0035		.016	2d foot	General sample; soil 18in.
80 acre field	1472	.0035		.037	24-30 in.	Gravel.

Description	Laboratory Number	Sodium Chloride per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
Clover field, general sample	1473	.0033	.0067			
Clover field, general sample	1474	.0033	.10	.037	1st foot	
Clover field, general sample	1475	.0066	.26	.075	2d foot	
Clover field, general sample	1476	.013	.42	.075	3d foot	
Clover field, general sample	1477	.0098	.076	.064	4th foot	
Clover field, general sample	1478	.013	.09	.064	5th foot	4½ ft. to gravel.
40 acre pasture near middle of field	1479	.0033	Trace	.021		General sample.
Pasture timothy and alsike.	1480	.0033	Trace	.032		
	1481	.06	Trace	.032		
H. Farris, Red Bluff.	1482	.0033	Trace	.021		
Riverside Park Great Falls,—						
about roots of dead trees.	1683	.35	.49	.037		
about roots of dead trees.	1684	.267	.48	.037	1st foot	
about roots of dead trees.	1685	.123	.30	.037	2d foot	
about roots of dead trees.	1686	.126	.289	.043	3d foot	

TABLES OF ANALYSES.

Description	Laboratory Number	Sodium Chloride per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
East of cornfield opposite R. R. depot, Poplar, Montana. 30 yards south of track.	1713	.007	.002	.058	1st foot	
	1714	.01	.04	.064	2d foot	
	1715	.01	.036	.059	3d foot	
	1716	.012	.61	.053	4th foot	
	1717	.012	1.72	.037	5th foot	
	1718	.016	.238	.101	6th foot	
	1719	.051	.166	.096	7th foot	
	1720	.21	.335	.075	8th foot	
	1721	.014	.102	.096	9th foot	
	17[illegible]	.009	.079	.096	10th foot	
	1723	.016	.079	.112	11th foot	
	1724	.009	.098	.112	12th foot	Water 12 ft.
Alfalfa field W. M. Wooldridge, Chinook, Mont. Section 27.	1725	.008	.027	.048	1st foot	
	1726	.003	.028	.053	2d foot	
	1727	.005	.06	.053	3d foot	
	1728	.026	.125	.043	4th foot	
	1729	.007	.075	.033	5th foot	
	1730	.015	.166	.032	6th foot	
	1731	.024	.42	.021	7th foot	
	1732	.049	.436	.021	8th foot	
	1733	.033	.174	.032	9th foot	
Poplar, Mont., corn field, gen,l sample.	1734	.0115	.033	.037		
Oat field of W. M. Wooldridge, Chinook	1735	.010	.032	.043	1st foot	
	1736	.0115	.13	.048	2d foot	
	1737	.051	.096	.048	3d foot	
	1738	.008	.213	.037	4th foot	
	1739	.007	.32	.048	5th foot	

Burns' oat field. Empire Cattle Co. Chinook, Mont.	1740	.01	.038	.048	1st foot	
	1741	.021	.085	.048	2d foot	
	1742	.033	.168	.069	3d foot	
	1743	.082	.44	.048	4th foot	
	1744	.074	1.48	.021	5th foot	
Road near Burns' house. Chinook.	1745	3.34	9.84	.128		Surface alkali.
McC Winiger, Kalispell,— Acme Dairy Farm, North Middle field.	2067	.013	Trace	.074	1st foot	Sec 32 T 29 N R 20 W.
	2068	.012	Trace	.032	2d foot	
	2069	.013	Trace	.032	3d foot	
	2070	.012	Trace	.037	4th foot	
Sec. 31 T 29 N R 20 W.	2071	.009	Trace	.037	1st foot	Bottom land.
	2072	.013	Trace	.037	2d foot	
	2073	.017	Trace	.116	3d foot	
	2074	.013	Trace	.111	4th foot	
Bottom Land	2075	.013	Trace	.069	2d foot	
	2076	.013	Trace	.058	3d foot	
	2077	.013	Trace	.069	4th foot	
White Streak, 1 inch thick.	2078	.012	Trace	.100		
L. A. Dorres, Malta,— Gumbo and alkali.	2079	.009	.050	.053	1st foot	
	2080	.017	.064	.069	2d foot	
	2081	.017	.222	.037	3d foot	
R. M. Trafton, Malta,— Sec. 18 T 30 N R 30 E.	2082	.009	.011	.042	1st foot	Pumping plant, Hooker & Caldwell, St. Louis. Lift 30 ft, from Milk River. 4500 gals. per minute. No signs of alkali.
	2083	.009	.023	.042	2d foot	
	2084	.010	.026	.048	3d foot	
	2085	.012	.046	.037	4th foot	
	2086	.015	.039	.048	5th foot	
	2087	.015	.050	.048	6th foot	
	2088	.015	.074	.042	7th foot	
	2089	.013	.079	.058	8th foot	

TABLES OF ANALYSES.

Description	Laboratory Number	Sodium Chloride per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
Great Northern Demonstration plats, Ashfield.	2090	.013	.032	.032		
	2100	.018	.067	.048		
	2101	.018	.404	.032		
	2102	.013	.815	.042		
Great Northern Demonstration plats, Hinsdale.	2103	.005	.320	.048		Gumbo.
	2104	.007	.026	.053		Sand.
	2105	.017	.047	.053		Sand.
	2106	.007	.432	.042		Gravel, local.
James Deegan,—Bottom land, 2½ miles east of Hinsdale.	2107	.003	.019	.042	1st foot	
	2108	.002	.015	.037	2d foot	
	2109	.002	Trace	.032	3d foot	
W. M. Wooldridge,—Bottom land east of Hinsdale.	2110	.010	Trace	.026	1st foot	Dark.
	2111	.017	.061	.037	2d foot	
	2112	.017	.124	.037	3d foot	Light.
	2113	.017	.067	.053	4th foot	
	2114	.013	.127	.026	5th foot	
J. W. Davis, Hinsdale.	2115	.007	.020	.058	1st foot	
	2116	.018	.022	.058	2d foot	
	2117	.020	.232	.053	3d foot	Alkali.
Lower Rock Creek Bottom, Hinsdale.	2118	.018	.646	.032	1st foot	
	2119	.015	.373	.032	2d foot	
	2120	.013	.541	.032	3d foot	
	2121	.013	.127	.042	4th foot	
	2122	.012	.140	.048	5th foot	

August Schwang, Hinsdale.	2123	.010	.065	.037	1st foot	Water stands at surface in spring.
	2124	.009	.705	.021	2d foot	
	2125	.009	.715	.032	3d foot	
Chas. Newmage, Hinsdale.	2126	.010	.026	.042	1st foot	
	2127	.010	.170	.032	2d foot	
	2128	..009	.213	.037	3d foot	
	2129	.010	.188	.048	4th foot	
	2130	.010	.690	.037	5th foot	
T. C. Power ranch, Sun River back of Turnell place.—	2131	.007	.625	.64	1st foot	Clayey soil.
Alfalfa poor, moist and clayey.	2132	.009	1.317	.048	2d foot	
Alfalfa poor, moist and clayey.	2133	.009	1.656	.048	3d foot	
300 yds. S.W. preceding, soil loose moist.	2134	.009	.545	.048	1st foot	Surface cracked.
Peppergrass and foxtail in possesion	2135	.009	Trace	.058		Alfalfa, timothy and grain, all failed.
Flume piece. Excellent soil, alfalfa fine.	2136	.009	.014	.090	1st foot	Mechanical condition perfect.
Sand.	2137	.003	.016	.058	2d foot	
Isaac Sears, near Plains,—						
Best orchard soil.	2138	.003	Trace	.064	1st foot	Sandy pulverulent.
Best orchard soil.	2139	.007	.005	.053	2d foot	
Best orchard soil.	2140	.009	Trace	.064	2½ feet	To gravel.
General sample of above.	2141	.003	Trace	.021		
Garden patch.	2142	.003	Trace	.011		Extra good soil, fine texture.
Orchard soil, nothing but apples do well.	2143	.003	.008	.011		Bakes.
A. L. Trent and Clayton, Plains.	2144	.023	.005	.021		Gained apple prize at Kalispell in 1900
Mrs. Lizzie Lynch, Plains,—						
Fine timothy meadow.	2145	.004	Trace	.095		Gravel, interfering with boring.
M. H. Pierce, Plains.—						
Garden patch, soil 18 ins. deep below slide rock hill.	2146	.007	.020	.032		Beneath, dark loam, potatoes.
Near above in Blackberry patch.	2147	.018	.083	.026		White efflorescence.

TABLES OF ANALYSES.

Description	Laboratory Number	Sodium Chloride per cent.	Sodium Sulphate per cent.	Sodium Carbonate per cent.	Depth	Remarks
Lorenz Helterlein, Plains, — Barley field, S.E.¼ Sec. 21, T 20, R 26 W.	2148	.003	Trace	.026	1st foot	Fine sandy soil.
	2149	.003	Trace	.016	2d foot	Valley unirrigated, drought this year.
	2150	.003	.005	.026	3d foot	
M. H. Pierce, Plains.— S.W.¼ Sec 22 T 20 N. R. 26 W.	2151	.005	Trace	.016	1st foot	
	2152	.005	Trace	.026	2d foot	
	2153	.003	Trace	.048	3d foot	
	2154	.003	.005	.069	4th foot	
	2155	.005	Trace	.133	5th foot	
	2156	.009	Trace	133	6th foot	
	2157	.005	Trace	.10	7th foot	
	2158	.005	Trace	.08	8th foot	
	2159	.003	Trace	.106.	9th foot	
	2160	.003	Trace	.032	10th foot	
J. R. Willis, Plains,— S. E. ¼ Sec. 27 T. 20 N. R. 26 W.	2161	.004	Trace	.154	1st foot	Gravel 10 to 12 ft,
	2162	.009	.034	.143		
	2163	.007	.015	.143		
	2164	.003	.011	.138		
	2165	.007	.007	.074	5th foot	Coarse sand.
C. C. Willis, Plains.— N. W. ¼ Sec. 27 T. 20 N. R. 26 W.	2166	.002	Trace	.026		
	2167	.003	Trace	.053		
	2168	.002	.61	.048		
	2169	.005	Trace	.037		
	2170	.003	Trace	.053		
J. Beckstead, Warm Springs,— 25 yds, N. hay corral.	2171	.081	1.047	.17	1st foot	Almost nothing growing.
	2172	.021	.160	.18	2d foot	

	2173	.017	.244	.085	3d foot	Gravel
75 yds. S. E. corral.	2174	.010	.102	.106	1st foot	Fine crop hay.
	2175	.009	.060	.074	2d foot	
	2176	.007	.041	.064	3d foot	
	2177	.005	.041	.064	4th foot	Gravel.
Bitter Root Stock Farm.—sandy, one of the best soils.						
Hamilton No. 3.	2182	.005	Trace	.032		Gravel 1ft., beets 20 tons per a., topped
Hamilton No. 2.	2183	.003	.040	.016		Gravelly soil, 4 tons topped.
West side.	2184	.004	Trace	.092		Sandy loam, 12 tons.
Pendergast No. 1.	2185	.004	.013	.074		Alkali bottom, 15 tons.
Pendergast No. 1.	2186	.126	.459	.085	1st foot	
	2187	.010	.034	.175	18 in	Gravel.
Gilchrist No. 1.	2188	.010	.020	.133	1st foot	
Gilchrist No. 1.	2189	.012	.029	.122	2d foot	
Gilchrist No. 1.	2190	.010	Trace	.085	3d foot	
Gilchrist No. 1.	2191	.012	.022	.053		General
Gilchrist No. 2.	2192	.005	Trace	.042		High land former orchard 10 to 12 ton.
Upper Ward No. 1.	2193	.003	.041	.037		Some alkali.
Upper Ward No. 1.	2194	.003	Trace	.053		
Upper Ward No. 1.	2195	.005	Trace	.016		General sample.
Lower Ward 1.	2196	.003	Trace	.026		Shallow soil 10 in. to gravel, 16 tons beets.
Ravalli 1.	2197	.007	.038	.021		Good soil 15 tons.
Rev. Wm. Cobleigh, Corvallis.	2198	.007	Trace	.037	1st foot	
Rev. Wm. Cobleigh, Corvallis.	2199	.007	Trace	.058	2d foot	Gravel.
Corvallis 1.	2200	.003	Trace	.021		Old feed corral, good yield.
Hamilton No. 4.	2201	.003	Trace	.053		Poor beets, very small.
Hamilton No. 1.	2202	.003	Trace	.053		Good beets.

SOILS FROM EXPERIMENT STATION.

Description	Laboratory Number	Phosphoric acid, per cent	Potash per cent	Sodium Sulphate per cent
Location No. 4, Clover field, 20 acres, S. W. corner of farm, soil 12 in deep, Gravel 4 feet 3 inches.	680	.16	.276	.015
Subsoil of above.	681	.17	.159	.017
Location No. 5. Clover field west of Station building, soil 12 inches deep, heads of clover mostly dead in small patch, rest of plant thrifty. Clover left for seed. 1st foot.	691	.14	.269	.017
Clover left for seed. 2nd foot	683			.08
Clover left for seed 3rd foot.	684			.04
Clover left for seed 4th foot.	685			.023
Location No. 6. Clover N. W. corner of farm, moister than location No. 5. Gravel and water 3 feet.	691	.14	.269	.01
Subsoil of 691	692	.17	.163	.015
Silt from north end of farm on beet plat.	693	.17	.219	.01
Rotation plats. No. 1. Wheat. Gravel 3 feet 9 inches. Soil 12 inches.	694	.18	.300	.013
Rotation plats No. 2. Peas. Gravel 4 ft. 6in. Soil 10 inches deep.	695	.17	.284	.006
Rotation plats No. 3. Oats. Gravel 3 ft., 6in. Soil 9 in. deep.	696	.16	.223	.017

Rotation plats No. 4. Beets. Gravel 3 ft. 9in. Soil 10 in. deep.	697	.17	.238	.009
Rotation plats No. 5. Barley. Gravel 3 feet 9 inches. Soil 8 inches deep.	698	.157	.206	.005
Rotation plats No. 6, clover. Gravel 4 feet 3 in. Soil 12 in. deep.	699	.15	.211	.01
Subsoil of 694	700	.17		.005
Subsoil of 695.	701	.15	.213	
Subsoil of 696	702	.14	.168	.005
Subsoil of 697	703	.158	.291	.001
Subsoil of 698	704	.16	.165	.009
Subsoil of 699.	705	.16	.180	.021

MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

F. B. LINFIELD, Director

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SECOND ANNUAL REPORT

OF THE

STATE ENTOMOLOGIST

BY

R. A. COOLEY

BOZEMAN, MONTANA
DECEMBER, 1904

Montana Agricultural College Experiment Station

BOZEMAN, MONTANA

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THE MONTANA EXPERIMENT STATION,
Bozeman, Montana.

NOTICE.—The Bulletins of the Experiment Station will be mailed free to any citizen of Montana on request. Please state whether all publications are desired as issued or only those specified. Give name and address plainly.

Cage at Missoula used for the study of the life-histories of the codling moth and the bud moth. The cage is 12x12 feet on the ground and 12 feet high.

CONTENTS.

THE ELM MEALY-BUG.

Phenacoccus dearnessi King.

While searching for cocoons of the codling moth under scales of bark of apple trees in Missoula in January, 1902, numerous cottony masses were found secreted under the scales and not visible except when the scales are picked off. These cottony masses contained the eggs and adults of a mealy-bug which I have referred to *Phenacoccus dearnessi* King. Specimens were sent to Prof. T. D. A. Cockerell, the American authority on these insects, and he replied that it appeared to be this species and on comparing it with the descriptions his conclusion was found to be correct.

On April 30th in the same vicinity in Missoula, numerous mealy-bugs, which later were found to be the same species, were found closely packed on elm buds which at that date were greatly swollen and about to open. See Fig. 1, 1. During the remainder of the

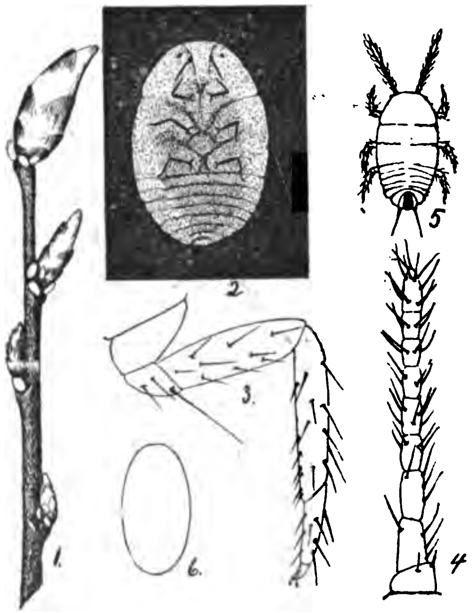

Fig. 1. The Elm Mealy Bug: 1, Mealy bugs at bases of buds of elm in spring of the year, natural size; 2, adult female from below, enlarged; 3, leg of female, enlarged: 4, antenna of female, enlarged; 5, newly hatched larva, enlarged; 6, egg, enlarged.

season of 1902 and in 1903 the species was commonly seen both on the apple and the elm at Missoula.

On making inquiry I learned from Mr. C. F. Dallman, proprietor of the Missoula nursery that this insect has at times been so abundant on the limbs and trunks of elms as to cause the leaves to wither. From the foregoing it appears that while the insect was originally found on the apple at Missoula it is more particularly a pest of the elm and that on that desirable shade tree it is capable of becoming a serious pest. So far as the notes in this office show, we have, beside this mealy-bug, only one serious pest of elms in Montana. This is the aphis which lives on the leaves causing them to curl and become deformed.

HISTORY OF THE SPECIES.

Phenacoccus dearnessi was originally described by Mr. Geo. B. King. Mr. John Dearness collected the original specimens from an old hawthorne tree near London, Ontario. The species has not been heard of since Mr. King's mention of it in Volume 33 of the Canadian Entomologist until this writing.

A RELATED SPECIES.

This mealy-bug is a member of the family of bugs scientifically known as *Coccidae*. To this family belong the true scale insects, soft scales, cottony cushion scale, the cochineal insect, and the lac insect. Altogether they form a very large and important group, there being upward of one-thousand five hundred species known to science. Another species in the same genus as the one that is the subject of this paper, has been injurious on maples in the eastern part of the United States. This species (*P. acericola* King) has about three broods during the year and does its damage by sucking the juices out of the leaves. The cottony masses on the under side of the leaves are conspicuous objects and where the insects become abundant they cause the leaves to become yellowish and sickly or drop off prematurely. The winter is passed by the young nymphs which secrete themselves in the crevices of the bark and there remain dormant. In the spring becoming active again they crawl to the leaves.

HABITS OF THE ELM MEALY-BUG.

We have learned but little of the life-history of the species found at Missoula but it is probable that it is similar to that of the maple-inhabiting species. However, it is plain from our observations that at least a part of the insects remain on the trunk of the apple throughout the summer. In fact, though we were often in the orchard in Missoula where this insect occurred in 1902, frequently running across clusters of the insects under the scales of bark, we did not in a single instance find any of them on the leaves. Occasionally we found the partly grown female insects crawling about the limbs and twigs but never attached and feeding except on the trunk. Under the scales of bark the insects were invariably found under the newly formed scales where the bark was of a light color and thin. The habit of the females in the spring of the year to cluster about the buds of the elm as shown in the accompanying figure, is a prominent one though we did not detect any injury done in this way. As the female insect feeds and grows she produces a very light and soft cottony mass about herself which is pure white. On coming to maturity the insect deposits her eggs in this cottony mass. When the young hatch from the eggs they work their way to the surface and go off to find a suitable place to secure food.

CONFUSED WITH THE WOOLLY APHIS.

It is a well known habit of the areal form of the woolly aphis to settle on newly made scars on the trunks of apple trees taking their nourishment through the tender tissues to be found there. This mealy-bug was found affecting apple trees in the same manner. So similar are the cottony masses of the two insects that the writer was able to be sure of the identity of the mealy-bug only by breaking apart the flocculent matter and examining the bodies themselves.

DESCRIPTIONS.

The male and female mealy-bug are very unlike in appearance. The male is very delicate and has long transparent wings, long legs, and long antennae. Its size is much less than that of the female which is about ⅛ of an inch long. With all secretions removed

the body of the female is yellowish in color. The legs and antennae are short and there are no wings. The female walks very slowly.

A technical description of the species is not given here but may be found on page 180, of Vol. XXXIII, Canadian Entomologist. 1901.

REMEDIES.

This pest may be controlled by the use of soap or kerosene washes applied to the trunks of the trees during the winter season. Its complete destruction will be facilitated by scraping off the loose outer bark before applying the wash. Kerosene emulsion and soap washes have been discussed in previous publications of this department of the Experiment Station.

THE STRAWBERRY CROWN-GIRDLER.

Otiorhynchus ovatus Linn.

The strawberry crown girdler was brought to the writer's attention as a pest in Montana in the summer of 1899 and since that time has been the subject of much interest in this office. The econcmic and biological features have been closely studied, but while we now make a report, it is not because we have learned all that we might on these subjects. More work might be done on the evasive problems connected with the life-history and methods of controlling the insect, but having reached a point where recommendations suggest themselves, it seems desirable to publish what information we have secured. We shall at the same time review the work of previous writers.

During the summer of 1902 observations of considerable value were made on the natural history of the species both in the field and in the laboratory, and again in 1903 facts of some value were secured. During the past summer (1904) Mr. Burle J. Jones, a graduate of the Montana Agricultural College and a thorough student of entomology, was stationed by this office at Missoula for the purpose of collecting insects and observing the habits of certain pests. He was informed of the status of our knowledge of this insect and instructed to closely observe its habits in order to verify our previous notes and if possible to secure new facts. Because of the fact that we were unable to have Mr. Jones in the field early in

the season and to keep him there until the close of the season, we did not have an opportunity to determine the number of broods of the beetle nor the stage in which most of the insects pass the winter. Mr. Jones made the observations on the effects of spraying with, and dipping in, arsenate of lead, and very carefully studied the habits of the insects during the three and a half months of his stay at Missoula.

GEOGRAPHICAL DISTRIBUTION.

The strawberry crown girdler is an introduced species, having come to this continent in all probability from Europe. It is known to occur in Europe and Siberia. In the United States it has been found from the Atlantic coast west to the state of Washington. The most southerly points at which it has been recorded are Alleghany, Pa., and Santa Fe, New Mexico. Both of these points are just within the southern boundary of the transitional life-zone and it is probable that this beetle finds its southern limit at about the line between the transitional and upper austral life-zones.

From the list of places given below, where the beetle has been recorded, it will be seen that though of foreign origin, this insect has become widely and generally distributed. Being entirely without wings it is dependent upon outside agencies for transportation except over such short distances as it can cover by walking. More will be said about the means of distribution in a later paragraph.

The following is a list of the records of the distribution of the strawberry crown-girdler.

Massachusetts, 1852, Henshaw. Cambridge, Mass., 1865, Henshaw. Cambridge, Mass., 1874, Henshaw. Wyoming, Mass., 1874, Henshaw. Alleghany, Pa., 1875, Wickham. Detroit, Mich., 1878, Wickham. Hanover, N. H., 1880, Henshaw. Buffalo, N. Y. 1882 (?) Wickham. New York, 1884, Lintner. "Southern Michigan," about 1882 or 1883, Weed. Ottawa, Canada, 1884, Harrington. Iowa City, Iowa, "not later than 1886," Wickham. Nova Scotia, 1889. Chicago, Ill., 1889Wayne Co., Ohio, 1892. Quebec, Canada, 1892. Indiana, 1892. New Jersey. Laramie, Wyoming, 1893, Wickham. Santa Fe, New Mexico, 1894, Wickham. Minnesota, 1895, Lugger. Missoula, 1897, Wilcox. Bozeman, Montana, 1899, Cooley. Helena, Montana, 1904, Cooley. Lake Washington, Wash., 1904, Melander (in Lit.)

COMMON NAMES.

This insect has been known in Mont. under the name of straw-berry-weevil, but since there are a number of other weevils that prey upon the strawberry, it would be advisable to use the more specific name first adopted by Prof. Weed, viz.: "The Strawberry Crown Girdler." In a reference in Insect Life (Vol. V, page 46) it is stated that in some localities the insect is known as the "graveyard bug." Professor Wickham, writing in Societas Entomologica (IX, page 131, 1894), states that Dr. Hamilton writing to him from Alleghany, Pa., stated: "I took this beetle in a cemetery here in 1875 and it was then apparently abundant. A couple of years afterwards it was excessively so in the same cemetery but now (1894) much less common than formerly." It may be that the beetle contracted the name of "graveyard bug" from its occurrence in the cemeteries of Alleghany as here quoted, but the literature does not make this point clear. There can be no reason why the insect should occur more abundantly in graveyards than elsewhere. Dr. Lugger in his short account of the beetle in Bulletin 66 of the Minnesota Experiment Station (1899) uses the common name, "The Pitchy-Legged Otiorhynchus." This name is obviously less desirable than "The Strawberry Crown Girdler."

FOOD PLANTS.

The following is a list of the plants on which this beetle feeds as shown by the literature of the species: borage (Cook), muskmellon (Webster), strawberry (Weed), currant (Mrs. Wickham), roots of blue grass (Webster), apple (?) (Lugger). The writer has found the larvae feeding on the roots of *Potentilla glandulosa*, a plant not distantly related to the strawberry, and has found the beetles hiding in abundance in the stools of this plant. The species was also taken feeding in the adult stage on the foliage of raspberry. Mr. Burle Jones found the roots of the plant commonly known as the "big root" or "balsam root" (*Balsamorhiza sagatata*) to be commonly attacked. He found fully one hundred weevils about one plant of this species and saw abundant signs of their attacks in other plants of this kind. Mrs. Williams of Missoula reports having found the larvae in great abundance on the roots of timothy grass.

As affecting the methods of controlling the ravages of this pest a knowledge of the food plants it is of great importance. More will be said on the subject under the head of remedies.

Only scattered observations on the feeding habits have been made as recorded above, but various writers have suggested that it is probable that the species feeds on a large variety of plants. Our observations bear out this belief. The food plants above recorded are widely scattered through the vegetable kingdom and it would not be surprising to find in a complete list, if such a list could be obtained, a very large number of widely differing plants.

Further observations on the feeding habits of this beetle in different parts of the United States are very desirable and might prove to be of great value.

INJURIOUSNESS.

In only two localities in this state has this pest become noticeably destructive, so far as we are informed. These two places are in Missoula Co., one being on the farm of Mr. Chas. Williams in the Rattlesnake Valley north of Missoula, and the other at the place of Mr. England west of the city. At Mr. England's place the beetles were very injurious about five years ago and drove him out of the business. He gave up attempting to grow strawberries for a period of four years, and then Mrs. England in the spring of 1904 set out a new bed not far from the old patch. So far as the experience of 1904 shows, no beetles are on the place. An explanation of this present freedom from the pest offers itself and is discussed under the head of remedies.

At the Williams place the beetles have prevented the profitable growing of strawberries for about eight or ten years. Great credit is due to these people for the persistence with which they have tried to overcome the pest. They have studied its habits both out of doors and in cages in the house and are remarkably familiar with its haunts and ways. They have moved their strawberry beds from one place to another all over their large and beautiful ranch and have invariably confronted the pest in each new spot. They have tried every means of control within their reach and have showed much ingenuity in their campaign but always at the time when the berries should be growing and coming to maturity, the vines gradually

weakened, because of the grubs at the root, and they harvested very poor crops. The beetle has shown itself capable of wiping out the strawberry industry in the territory in which it operates. Up to this time we have been powerless to check its ravages.

Fortunately it spreads very slowly or else is closely confined to certain soil conditions. It has been a matter of much interest to us that on the farm adjoining that of Mr. Williams, just across the road and an irrigating ditch, strawberries have been grown very successfully. On one occasion I entered this field and found very luxurious foliage and saw the pickers harvesting a full crop of berries, while at the Williams place the crop was destroyed. After five years' experience with the insect we feel warranted in saying that it is probable that it is quite definitely confined in restricted localities and that excessive injury will result only when it is attempted to grow strawberries in these localities. In driving up the Bitter Root valley in the summer of 1902, I stopped by the road and collected insects. It developed that I was in the midst of a colony of this beetle. Masses of their dead bodies were to be found under pieces of bark on the ground. So far as I was able to learn no one has ever grown strawberries within several miles of this spot. The limits of this colony were not far off and beyond the limits no beetles were found. The fact that the species is gregarious in habits may in part, but does not fully, explain this marked tendency to live in limited areas. Further, it may be said that the presence of the beetle in a strawberry field in small numbers is not necessarily an indication that it will increase and become injurious. Though we have found the beetle in garden patches of strawberries in the city of Missoula we have never had a complaint from that city.

It is not a usual practice to continue to grow strawberries on one piece of ground year after year, and though a few specimens may be brought into a bed it is not probable that they will multiply with sufficient rapidity to become seriously injurious before the bed is abandoned. We believe that serious injury will be done only where strawberry beds are planted on fields where the beetles are already present in abundance. Literature shows no record of extensive injuries from this insect though its possibilites as a pest have been mentioned.

INJURIES TO PLANTS OTHER THAN THE STRAWBERRY.

It should be borne in mind that this beetle, being a very general feeder, may develop into a pest of various other plants. As we have mentioned under our discussion of food plants the larvae are said to feed voraciously on the roots of timothy grass. We may therefore expect it to be very injurious to crops of timothy that are planted in territory which it has invaded. There is nothing to assure us that it will not seriously injure various other crops.

NATURE OF ATTACK.

The adult beetles feed on the foliage of the strawberry and the larvae feed on the roots. In an old bed one or more years of age, the injury done to the foliage does not appear to be serious but on newly set plants in the spring or early summer, the beetles come in such numbers, eating the foliage and boring holes in the stems, as to destroy the bed before it gets a fair start. The experience of Mr. Williams has been that during the first summer when the plants were small and just getting started, here and there a plant would be killed. The next summer more would die and in the third summer, at the time fruit is growing, many plants would die owing to the large number of grubs at the roots. At the time the full crop should be expected the bed may be so invaded that not more than one plant in ten to twenty of those that were set out is left.

The beetles eat irregular patches out of the leaves as shown in plate II, fig. 2. This is a newly set plant photographed in the field. It is not uncommon to find from fifteen to thirty beetles hiding about a single young plant.

The larvae feed on the roots and kill the plants outright. A plant that is dead or nearly dead from this cause has many of its larger roots eaten off and is more easily removed from the earth than a healthy one. The younger larvae appear to feed on the fine rootlets some distance away from the crown of the plant, and as they grow older they work their way up the roots, many of them eventually reaching the crown or dense masses of roots just beneath the crown. I have never found a larva of this species really imbedded in the crown. They seem to prefer the more exterior parts just where the roots arise. Where they feed, a powdery brown substance, their castings, is to be seen. They also feed from the surface of the lower part of the crown more or less completely girdling the plant.

DESCRIPTIONS AND NATURAL HISTORY.

The general appearance of the adult beetle is well shown in the accompanying photographs, (see Plate I, figs. 1 and 2). These photographs are greatly enlarged but the beetle is also shown in natural size above and to the right of figure 1. When first emerged the beetles are light brown in color but they soon take on a permanent brownish black. The antennae are elbowed and are slightly enlarged at the very tip. The shell of the beetle is very hard.

Most beetles have a pair of wings folded beneath the hard horny wingcovers that overlie the abdomen or posterior part of the body, but in the case of the beetle in question no wings are present and the wing-covers are grown together in such a way that they could not be raised as in flight if the wings were present. The beetle therefore is as incapable of flight as a toad and for locomotion is dependent on walking or on outside agencies.

The adults are nocturnal in habits and gregarious. When disturbed they draw in their legs and play 'possum.

On examining the earth around strawberry plants affected with the adult beetles one finds small open holes that lead into the earth toward the roots. Carefully following these holes with a straw or the point of a knife blade the beetles may be found often in considerable numbers. These holes often follow the stems of leaves of plants that are newly set, being often just under and parallel with the stems. Other holes follow down under small clods of soil or other objects. Other beetles may be found under partly covered leaves and many may be found scattered through the soil about the roots Among old plants they often crawl down into the crown where the new and old leaf-stems arise. In all such places they spend the day, coming out to feed during the night.

It appears that the beetles are more or less dependent upon food in order that they may develop ova. Our investigations have shown plainly that the beetles crawl about in the soil for the purpose of scattering their eggs. On our potted plants used for studying the beetles we found some eggs on the surface of the soil and a few even on the under surface of the leaves, but we believe that the normal place for egg deposition is in the soil. The soil in the pots was harder than is natural for out-of-door conditions and some of the

leaves were close to the earth. Many of the eggs in the pot experiment were found to be in the burrows and in the little cavities used by the beetles as retreats from the light. This habit of the beetle of scattering the eggs among the roots is perhaps nature's method of making sure that the very small weak larvae shall not fail to secure food, for it is very doubtful if the newly hatched young could make their way through the soil to the roots.

The habit of congregating in large numbers in darkened places is a marked one with this beetle and large numbers have often been found in houses under carpets and in similar places. Mrs. Williams' house was invaded by them and this peculiarity has been more often mentioned in literature than any other.

The gregarious habit is also shown when the beetles go into hibernation, for in the spring of the year under clods of earth, under stones, boards, etc. the beetles may be found in great abundance.

THE EGG STAGE.

The eggs of this beetle are very minute objects measuring only about .25 mm. long. The general shape and appearance are well shown at figure 4, plate I. When first laid the eggs are milky white but a little later they take on a pale brownish color.

We can closely judge of the duration of the egg stage from the following experiment. On May 31st, 1902 I brought living beetles from Missoula to Bozeman and on June 2nd ten beetles each were put on five strawberry plants in pots at the Experiment Station. On June 7th a few eggs were found. The eggs became more and more abundant and on the 21st there were many eggs to be found. The soil was not examined again until June 27th when a few young larvae were to be found. It thus appears that about twenty days or a little less are required for the eggs to hatch.

On June 27th the eggs were very abundant and it was roughly estimated that there were 200 eggs in one can. It was impossible to accurately count them. It will be remembered that ten beetles were placed on each plant and if one-half of these were males, the five females laid at the rate of forty eggs apiece. In making the examination, so much of the soil was removed from the roots of the plants that the plant which had already been weakened by the attacks of the beetles could not be kept alive longer; otherwise it is probable that more eggs would have been deposited.

THE LARVA.

The newly hatched larva resembles the older larva in shape and color but is much smaller, being almost microscopic in size. They feed on the fine rootlets and in a soft soil are perfectly at home, getting about slowly but with ease.

The older larva is a conspicuous object against a back ground of dark soil being itself almost white in color with a yellowsh head. See figure 6, plate I and figure 1, plate II.

We have nothing to indicate to us definitely the duration of the larval stage.

THE PUPA.

When full-fed and ready to pupate, the larva constructs an oblong cell in the soil and casting its skin becomes a pupa. See plate I, figure 5. In this cell the helpless pupa remains until the adult stage is reached.

The pupa is almost pure white, very soft and delicate, and shows distinctly the various parts which in adult life will be known as legs, antennae, beak, wings, etc. It is noticeable that the wing-sacs are separate along the line of the back, while in transforming to the adult stage they become fused forming one piece.

NUMBER OF BROODS AND HIBERNATION.

We can state definitely that the winter is passed both in the adult stage and as larvae. It may be also that some individuals pass the winter as pupae. As early as August the beetles begin to show a tendency to come together to go into hibernation quarters and yet in the fall and spring larvae may be found in the soil. The different stages so everlap each other that one can find eggs, larvae, pupae and adults all at the same time and this condition leads to much confusion in an attempt to determine the number of broods, We can give but little evidence as to the number though we hold the opinion that there is but one brood each year.

MEANS BY WHICH THE CROWN GIRDLER SPREADS.

It is a remarkable fact that though this insect possesses no wings and cannot fly, it is capable of widely distributng itself as is shown by the records of its occurrence. It is a slow walker, practically speaking, and is dependent upon outside means for its distribution. Very likely it has been distributed to some extent on strawberry plants sent for planting new fields. Its desire to avoid light would naturally lead it to retreat not only into houses, as has been recorded, but also into barns and other buildings as well as boxes, farm machinery, and any other objects whatsoever that offer desirable places of retreat. In any such objects that become articles of commerce or are removed from one place to another for any purpose, such as household goods, etc. carried by persons moving from one place to another, the beetles are liable to be taken into a new locality, and once in the new locality, being adapted to a large number of wild-growing and cultivated plants, they stand a fair chance of becoming established.

NATURAL ENEMIES.

We have observed no parasitic enemies of this beetle and Professor Weed bred none though he confined many of the insects for the purpose. Mrs. Williams reported to me that the domestic fowls followed the plough in the spring ravenously eating the early stages, which because of their white color, were conspicuous objects. Mr. Weed reported that he found the predaceous larvae of *Carabid* or ground beetles in the earth around the roots of strawberries that were attacked by the girdler larvae.

REMEDIES.

The two general methods of restraining this pest that suggest themselves are the use of a poisonous spray and the use of such cultural practices as interrupt the life cycle of the beetle.

Mrs. Williams informed me that she had made a thorough test of the use of Paris green as a means of poisoning the adults on the foliage and had not been able to kill them. Knowing the general characteristics of the beetles we were not surprised at the results secured in the test and decided not to make any further tests with Paris green.

EXPLANATION OF PLATES.

Photographed from nature from specimens secured at Missoula, Montana. The natural size of the various stages is shown in the small circles, except in the case of the egg which is almost microscopic in size.

PLATE I.

Figure 1. The adult beetle from the side.
Figure 2. Top view of the adult beetle.
Figure 3. Top view of the pupa.
Figure 4. The egg greatly enlarged.
Figure 5. Ventral view of the pupa.
Figure 6. The larva.

PLATE II.

Figure 1. Larvae taken from the roots of one strawberry plant
Figure 2. Strawberry plant showing foliage eaten by the adults of the strawberry crown girdler.

PLATE I.

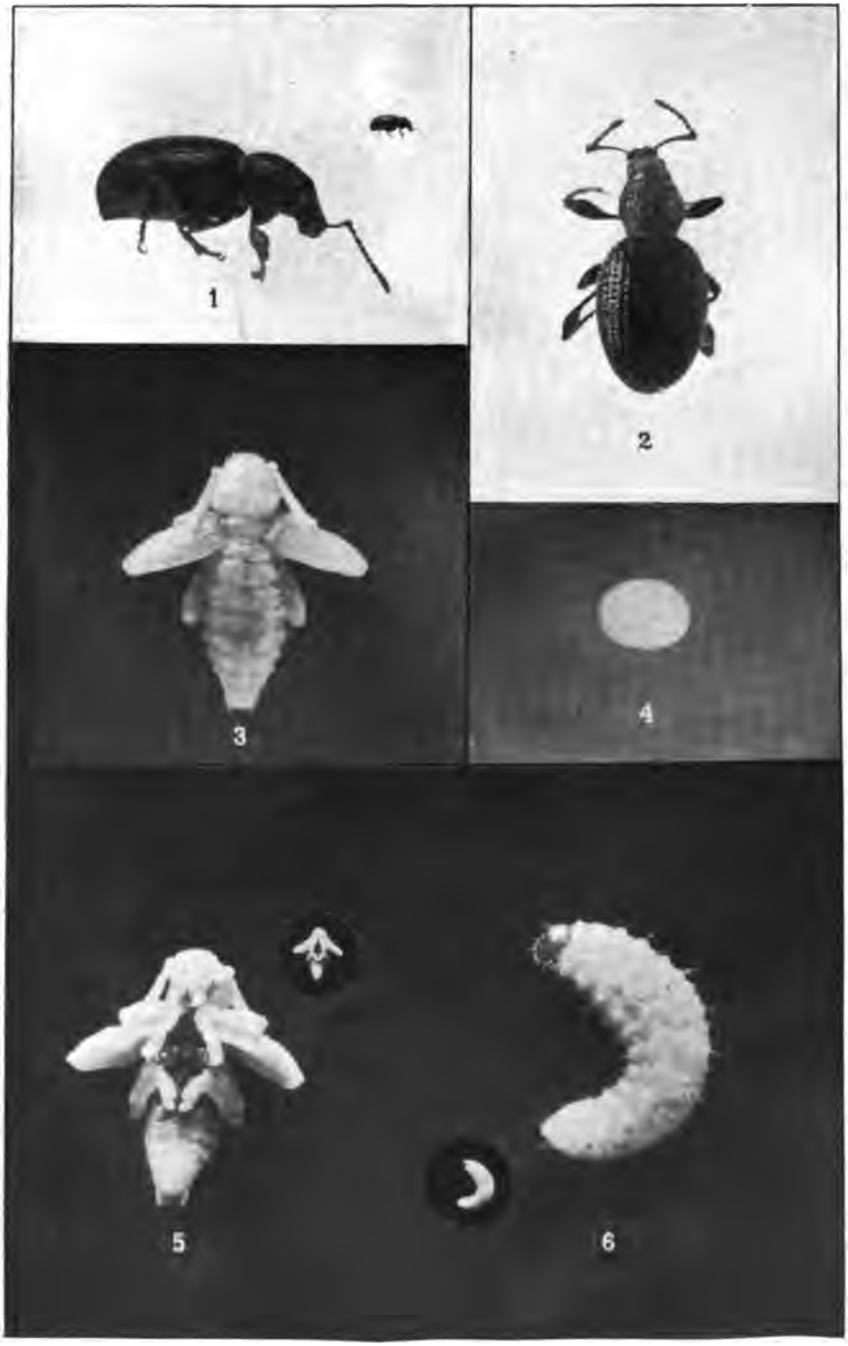

PLATE II.

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DIPPING IN ARSENATE OF LEAD.

At the writer's suggestion arsenate of lead, secured from the Bowker Insecticide Company, was used. This substance has certain marked advantages over Paris green as an arsenical insecticide for use on the foliage of plants. Being insoluble in water it may be applied to tender leaves in much greater strength than is safe with Paris green. And there are very few insects, if any, that cannot be killed by it or driven from the plants sprayed with it. Moreover, it remains on the foliage much more persistently than does Paris green, and hence is very desirable in a climate with frequent rains that would easily wash off an application of Paris green.

We suggested to Mrs. Williams that she try dipping her plants in the substance before planting them in the field and then follow up this treatment with later sprays as new foliage appeared. It was felt that if the beetles could be driven off from the new plants the bed would be free ever afterward.

Mr. Jones watched this test and reported that dipped plants were entirely immune for about two weeks after setting and after that length of time the beetles gradually appeared and fed on the new growth that was being put forth. The foliage was then sprayed and the plants were again immune, but it was noticed that the plants were not doing well and it was found that the ingenious beetles were feeding on the roots! It will be remembered that it is the habit of these beetles to hide among the roots in the soft soil and it is not surprising, that impelled by hunger, they fell to feeding on the roots. Beside finding the roots of the plants gnawed, Mr. Jones took the trouble to make a microscopic examination of the contents of the intestine and concluded that it was composed of what had been eaten from the roots of the strawberry. The practical conclusion drawn from this test is that, while the use of arsenate of lead in the manner indicated cannot be relied upon to keep the bed free from the beetle, the treatment is probably very much better than nothing. Dipping the plants before setting them is easily done and the cost and trouble of spraying two or three times with arsenate of lead at the rate of five pounds to fifty gallons of water is not great.

The one result of our investigations that appears to be of greatest practical significance is the discovery of the fact that the trouble from the pest arises from the presence of great numbers of the

beetles, and their larvae, in the earth, living on natural food-plants at the time the soil is broken up for the planting in strawberries. Therefore the remedial measure that seems to promise most is so managing the soil that when it is desired to set out the field to strawberries the beetles will have been previously starved out; in other words the use of a cultural method. We have not had opportunity to make a practical test of this promising method but we are reminded in this connection that Mr. England, who lives just west of Missoula, some years ago was so troubled with this insect that he abandoned strawberry growing entirely, using the land for other crops. Mrs. England started in again to grow some plants, in a small way in the summer of 1904, and had no trouble whatever with the insects.

Mr. Williams' trouble has been principally on newly broken, virgin soil and we feel that if he had allowed the soil to lie fallow for one season, keeping it free from vegetation, he would have been troubled only in so far as the beetles are able to migrate into the field from the sides.

While the beetles are very general feeders, it is probable that there are crops that could be tilled that would be let alone by them and it is desirable to try planting potatoes and some other common crops, making critical examinations of the roots from time to time to learn if they are eaten by the larvae. If potatoes or any other crop is found to be immune, it may be used on virgin soil infected with this beetle and followed the next season by strawberries.

NOTES ON THE BUD MOTH.

By B. J. JONES.[1]

This insect was discussed at considerable length in the Entomologist's Report for 1903. Conditions were found to be so favorable in the cage at Missoula, however, that it was thought best to make a further critical study of it there during the summer of 1904. As the work began May 12th and ended August 22nd this study of course did not deal with the first spring activities or with the winter hibernation of the pest. The present publication may be regarded as dealing with the seasonal dates and peculiarities of its transformation, and establishes, as we believe very conclusively, a number of points in the life-history which differ considerably, in this state at at least, from the ordinary routine as worked out and published in the very excellent works of Professor Slingerland and others. As these differences have much to do with the possible effectiveness of insecticides they will be given special prominence in the present discussion, while other points already established will not be considered.

It was estimated that fully two-thirds of the flower buds on the tree in the cage, from which all of the observations were taken had been destroyed by the young larvae. Under date of May 12th it was recorded that, though varying somewhat in size, the larvae measured almost uniformly one-fourth inch in length. They were rolled tightly in dead leaves, were practically inactive during the day, and seemed quite invulnerable to any possible application of spray. They were quite dark in color and apparently ready for the first spring molt. Two days later this theory was verified, for a number of larger, fresh larvae were found in the early morning migrating from the former hibernacula and establishing themselves upon new and larger leaves. The migration soon became general and a large per cent of the worms were found to move to other quarters where they were for some time uncovered and susceptible to spray

1. The work on the bud moth at Missoula in the summer of 1904 was conducted by Mr. Burle J. Jones, a graduate from the Montana Agricultural College in the class of 1904. The outline of the work that we desired done was given him and the special problems indicated. Mr. Jones is a conscientious observer and promising student of economic entomology.

while constructing the new retreats. In building its cocoon the larva usually selected a position along the mid-rib of the leaf and began to weave a silken web back and forth, using mouth and feet. After a considerable net-work had been spun this operation was suspended and the worm proceeded to tap the mid-rib near the petiole, or the petiole itself, in such a way as to cut off the food supply. The elastic threads draw the edges of the leaf together as it wilts and, aided by the larva within, soon it is doubled, forming a secure hiding place. As the leaf withers and droops it naturally touches others of the cluster and is skilfully attached to them by its busy inhabitant. This serves a double purpose since it prevents the withered leaf from dropping and provides a very convenient feeding ground for the worm. The hibernaculum is continually enlarged and strengthened with silk, frass and scraps of leaves. In a few days it became evident that the larvae must emerge from these withered leaves in order to obtain food. This indeed was found to be the case, and each morning showed signs of renewed attacks upon the surrounding foliage. In the early morning, especially on dark, cloudy days, a large percent of them were actively engaged in these exposed places, retiring to the nest in the bright hours of the day. As a rule these feeding grounds were entirely free from the nest and upon exposed surfaces of the leaves since the larvae in this stage do not feed upon the epidermis of the under side. This propensity to migrate to new quarters did not seem to be due to the fact that the tree was so badly infested, as might be expected, for even in this case there was seldom more than a single worm in the cluster of leaves from one twig. It was rather due to the fact that the former quarters were not only unfit for the growing worm but were also usually a considerable distance, comparatively, from desirable food. In a few cases the larvae remained in the original hibernacula, but a careful estimate showed that about 75 per cent of them did actually migrate and establish new homes. The general trend of the moving was from the center of the bole and larger limbs where the winter cocoons were spun toward the outer and younger growth.

At no time during its larval stage does the insect eat as voraciously and grow as rapidly as during this interval between the first and second spring molts, so that a considerable surface is actually repre-

sented by the feeding grounds; the caterpillars often continue their activity until the morning is well advanced. They attain to a length of between 8 and 10 mm. before retiring for the second shedding of the skin. It became evident then that this period would be especially favorable for the first experiment in spraying. Accordingly, on May 25th a limb of the tree containing 90 hibernacula by actual count was given a thorough coat of Arsenate of Lead in about the proportion of 5 pounds to 50 gallons of water. A tarred band was placed about the base of the limb to prevent migration to other parts of the tree and the ground beneath was covered by a sheet to ascertain whether or not the worms would drop to the ground, either as a means of escape or when overcome by the poison. After about two days it was evident that they were not pursuing their usual habits. Late in the day there were a number moving about on the leaves as though still in search of desirable food; many of these were on the under side of the leaves which were not so heavily coated with poison. They did not feed here, however, and even the customary haunts did not show signs of having been visited. The worms did not grow and soon began to show the effects of their abstinence; some very evidently died of poison and others shrivelled and died in the cocoons. About a fourth of the cocoons were empty and a small per cent of the larvae were found to drop to the sheet, these however were entirely those suffering from poison so that they were unable to attach their threads to the leaves.

Many ants, beetles and spiders were running about over the sheet and some were even seen carrying larvae away. An estimate of 75 per cent was recorded in the notes for the insects destroyed by this spraying, and there was no appreciable damage done to the foliage by the insects after it was applied. A final examination was made after pupation had begun and it was found that only a single worm had attained to the pupa stage.

Pupation began June 7th and by the 10th about a third of the insects were in this stage. It was often undertaken in the last hibernacula but it was especially noticeable that as many as half of the worms constructed new cocoons. These were almost entirely the product of the spinnerets, were constructed in the same way and attached in the same places as the winter hibernacula. Often the old winter quarters themselves were reconstructed and utilized for

this purpose. Though the larvae had maintained a comparative uniformity of size, the pupation lasted over a month and it was August 1st before the last belated pupa emerged as an adult moth. Branches were clipped from the tree and kept in water under small globe cages where the length of the stage was carefully recorded from the first morning after pupation until the emergence of the moth. A number of careful estimates were also made in numbered localities in the limbs. Of six successfully reared in the cans the length of the stage was as follows: 10, 13, 15, 16, 17 and 18 days, giving an average of 14 and five-sixths. Those followed in the tree gave practically the same results. This would seem to be accurate since it was June 25th before there was a general emergence of moths. On July 2nd the first eggs appeared in considerable numbers. The females did not seem to be as careful in selecting places for the deposition of the eggs as those of the codling moth, which had also laid in abundance both in and about the cage. Those of the bud moth were laid irregularly over the upper and lower surface of the leaves, the latter being considerably in the minority although still quite prominent. The eggs when immediately compared with those of the codling moth are seen to be considerably smaller, but under ordinary magnification there seems to be no definate difference in the markings. Contrary to the previous records in this State the eggs were found to be occasionally laid in clusters of from 3 to 8, sometimes slightly overlapping. This might have been due to the fact that the tree was so badly infested, though it was recorded in more eastern localities as being the ordinary method of laying. The preference of the moth for the upper side of the leaves seems to lie in the fact that it is not pubescent and the egg can be better cemented down to prevent the entrance of air. This is apparently an important item since the egg soon dies if the leaf be removed and wrinkles by wilting, or if the edge of the egg be raised ever so slightly. When laid on the under side the eggs are always carefully cemented to the surface beneath the larger hairs of the leaf. Whether this is done by the parent or is due to the plastic and adhesive properties of the eggs themselves is still, I believe, undetermined. After from 4 to 5 days the eggs turn yellowish like the yolk of a hen's egg and by the sixth day a number of reddish dots appear. A day or two before

hatching the black head and thoracic shield of the larvae show through distinctly. A number of eggs were carefully marked by means of bits of paper, string etc. and a weighted average of 11 days was obtained as the length of this stage. In laying the eggs the moths avoided almost entirely the branch of the tree sprayed on May 25th which still retained a considerable coating of the poison.

The first of the larvae began to appear on June 11 and by the 20th the insect was practically again in this stage. When free from the egg the minute larvae proceed at once to the under side of the leaves and begin to feed along the mid-rib or some of its larger branches. Usually they burrow down between the upper and lower skins of the leaf feeding and at the same time covering themselves over with frass and the pubescence of the leaves, which they weave into a solid mass by the use of their spinnerets and ever ready supply of silk. At no time in its existence as a larva is the insect without this string of silk, and wherever it is the end of this life line is always anchored securely. They have been seen to drop a distance of 3 or 4 feet before being stopped by this minute thread, and after waiting a moment for the intruder to leave wriggle back by a whirling motion to the place of attachment. With the younger lighter larvae this is a simple task but the heavy-bodied adult often breaks its life line and drops. When affected by poison the worm often neglects, or is unable to attach its thread and while throwing itself about blindly will often fall to the ground. At first the miniature grub feeds very slowly and it is some time before the feeding grounds are enlarged to any considerable extent. During this time the larvae are so closely covered by their cocoons and hidden behind the leaf veins that they are practically immune from spray or any kind. After about 14 days however they begin again to have a definite routine, making nightly rounds from their cocoons to the more distant parts of the leaves. As they grow and extend their ravages they are of course more unprotected and feed upon a greater per cent of the exposed cuticle. At about this time the grubs apparently foresee a need of extra supplies and as their habitats wither they begin to stick other leaves to them. This is done very skillfully and cleverly; the flat surfaces of the leaves are fastened together and the worms feed within, free from any possible invader. At the first indications of this propensity it was seen that the leaves

must be coated with poison before they were fastened together and on July 15th, before a large per cent of the worms had begun to fasten the leaves together, a part of the tree was given a thorough spraying of arsenate of lead in nearly twice as strong a solution as that formerly applied. Special attention was given to coating the under side of the leaves.

It was naturally some time before the effect of this spraying became evident, since it was not until about July 30th that the process of fastening leaves together in the construction of the so-called houses, which has been so thoroughly discussed in previous publications, began to come into prominence on other parts of the tree. It was now noticeable that these transformations were not going on in the sprayed limbs. A careful examination of the larvae here showed that while they were largely still active, bewteen 5 and 10 per cent only being found dead, yet their ravages had been confined almost entirely to the leaves upon which they had hatched,and that even here the feeding was far down under the coating of poison and not extended as in other parts of the tree. On August 6th the per cent of dead larvae on the sprayed limbs had increased considerably and there was very little noticeable extending of the feeding grounds. By August 18th the condition was still more aggravated, and when on the 22nd a final examination was made the effect of the poison was very evident. On unsprayed parts of the tree the leaves were largely turning brown as a result of the ravages of the worm and the "Houses" consisted of from 2 to 5 leaves. The sprayed parts were practically free from clusters of leaves fastened together, and the foliage was still fresh and green. Though a small per cent of the worms were still alive they were not developing as rapidly as the others and, judging from the observations taken at the first spraying, would never live to go into winter quarters.

The summer was unusually dry and only two heavy rains had takn place since the first spraying on May 25th. That limb was now, on August 22nd, by far the freshest on the tree and most free from attack, and still retained a considerable film of the Arsenate of Lead.

While the experiments given above were limited in their application they certainly show that the range of control of this pest is much wider than was formerly supposed. The fact that the larva

feeds entirely on the leaves after its first spring attack on the opening buds, makes its control a much more tangible problem than that of the codling moth, where the surface feeding is confined to the single hole which it makes in the fruit,; and the fact that the bud moth is actually without covering during a part of the larva stage and feeds upon exposed surfaces, makes the problem still more simple. This does not mean that the insect does not require the most rigid and persistent treatment, nor is it intended to indicate that it will fall an easy prey to an ill-timed and carelessly applied application of poison.

WHEN TO SPRAY.

Certainly the best time for the first application is in the spring before the flower buds begin to open. The cocoons of the insect should be closely watched and the spray applied as soon as there are signs of activity, or even before if the area to be covered is large enough to consume a considerable length of time, since it is fatal to allow the worms to enter the young buds. The larvae are already advanced in size and have only to proceed to the opening flowers of the nearest twigs, which, by a remarkable instinct of the worms when hibernating in the fall, are usually upon those at the base of which their cocoons are securely fastened, in order to do immediate damage. It is this stage that the orchardist should be especially anxious to control since it is at this time that the damage is done and when the insects are allowed to get well within the opening flowers they are practically safe until the apple crop has been "Nipped in the bud." At this time, however, they are feeling the effects of a long winter's fast and will be very susceptible to the poison if it be very completely and thoroughly spread. But the applications should not end with this, and if there are worms still to be found on the tree, and a few are certain to survive even the most rigid treatment, their habits should be closely watched and as soon as they begin to feed in exposed places they should be again treated to spray. This application should be made at the time that the larvae complete the first spring molt and begin to seek new and larger quarters, such a stage as that described above which occured about May 25th at Missoula. Even after the summer brood emerges from the eggs the prudent orchardist will find it to his advantage

to pursue them with the ever ready spray pump and nozzle, before they begin to fasten the leaves together. The disadvantages of spraying at this time are: that it is rather difficult to get a thorough coat of poison on the under side of the leaves where the worms are now feeding, that the pubescence of the under side prevents the spray from adhering as closely and uniformly as above, and finally that the fruit, where the trees are bearing, is now ripening in many cases and there is more or less danger of having a coat of poison upon it when it is ready for market; the application can be timed, however, in most cases so as to avoid this trouble. A coat applied when the eggs were still unhatched would cleave sufficiently to make life very uncertain for the resulting larvae. The advantages of spraying at this time are: that the leaf buds have ceased to grow and the spray is good as long as it retains its poisonous properties, since there is no danger of the trees outgrowing it and making fresh feeding grounds for the worms as is the case with the earlier applications. In this advanced stage the foliage is also very resistant and the mixture can be applied at a greater strength than formerly, which up to a certain limit, makes it much more adhesive. As a general rule where trees are infested by this insect keep the the early buds and blossoms sprayed by all means, whether it requires one, two, or three applications, and spray later if the insect is still present.

HOW TO SPRAY.

This has been widely discussed in bulletins dealing entirely with the subject of spraying and requires only a word here. As a complete and even distribution of the spray is the principal thing to be attained in dealing with this insect a Vermorel, or similar nozzle that will give a wide and fine distribution to the liquid, should be used. In putting on the first spray the operator should not confine his attention to the buds alone but should give the leaves a thorough coating, since the object is not only to keep the insect from doing immediate damage, but to kill it if possible. This of course should be done from an elevated platform, or by means of a long bamboo stick or rod attached to the nozzle so that the topmost branches can be reached and the upper side of the leaves thoroughly covered. In dealing with the summer brood it is

necessary to thrust the apparatus through the limbs in such a way as to coat the under side of the leaves. The operator had best protect himself from drippings by rubber garments or old clothing for which he has no further use. With arsenate of lead it is always necessary to keep the mixture within the pump well churned in order to get an even distribution of the poison, as the heavy lead compound settles rapidly. This is best accomplished by the use of a pump with an agitator provided for that special purpose, but may be done on a small scale by frequently turning the spray back upon itself through the nozzle, or by other methods of churning.

WHAT TO SPRAY WITH.

As the experiments recorded above dealt only with arsenate of lead we can of course give its relative value with other sprays only by the results obtained from their use in other localities. It is only fair to say in this connection that in the present instance it has given much better results than those recorded from the use of others in other places where it was reported that their effectiveness was not encouraging. It is especially favorable for the first spring application as the young buds at that time are quite delicate and will not always withstand the Paris green compounds, which are likely to burn them at that rainy season of the year. The arsenate can be safely applied at that time in the proportion of four and a half to five pounds in 50 gallons of water; the second dose, if it be applied after the blossoms have gone, may be increased to 5 and a half or six pounds, and the third as much higher as the condition of the fruit will allow.

NATURAL ENEMIES OF THE BUD MOTH.

The natural enemies of this pest must not be overlooked since they form no small element in its control. The enormous multiplication of the moth within the wire screen composing the cage as compared with neighboring trees outside, shows the remarkable effectiveness of birds and the larger insects in reducing its numbers. Within the cage numerous parasites were always in evidence. It was found that larvae or pupae left about the cage were invariably taken by ants which were always running up and down the trees

and over the ground. A number of instances came to my attention during the summer where these doughty little soldiers had found unprotected larvae and were struggling away down the tree with them. A small per cent of the pupa cases opened were found to contains Chalcid flies in various stages of existence. Usually these had devoured the pupae and were completing their transformations neatly enclosed in the pupae of their former hosts. Quantities of large gray spiders were always in and about the tree and in the crevices of the cage.. In a number of cases the adult spider built her nest and laid her eggs upon leaves containing bud moth larvae. These spiders were most noticeable during the pupation period in July and it was found that the crevices of the cage were filled with cocoons of the bud moth containing adult larvae or pupae. Nests containing young spiders were invariably stored with them and the cocoons were speedily emptied by the young Arachnids. While it is never safe to rely entirely upon natural enemies for the control of the pest, yet they deserve a large share in the orchardists's consideration and should never be destroyed by him.

SOME INSECTS TO BE WATCHED FOR BY OUR INSPECTORS AND FRUITGROWERS.

We have attempted to bring together in the following pages information that will be of value to our horticultural inspectors, fruitgrowers and others interested in the preventive campaign Montana is making against insect pests of fruit. We believe that the geographical arrangement of the valleys of Montana which have climatic conditions that permit of the successful growing of fruits make it possible to do much to prevent the introduction and spread of insects and fungus pests. The different fruit regions are so isolated one from another that pests from any one infested region in the state are scarcely more liable to be transferred to another than are the pests from an infested region outside of the state. It is therefore of the greatest importance that all persons interested in the fruit industry should acquaint themselves with the appearance of the pests that are most liable to be introduced. We have included in the list here discussed, various species that have appeared in one

or another locality while those that are already widely distributed and well known, such as the apple leaf-aphis, have been excluded.

Not all of the species in the list can be considered to be pests of first class importance in our climate but they are all species that for one reason or another, usually because they feed in the fruits that are liable to be shipped into the state or because they hibernate in or on some part of the trees that are shipped in as nursery stock, are liable to come across our borders incidentally in commercial practices.

THE PEACH-TREE BORER.

Though the peach-tree borer shows a decided preference for peach trees it is also a pest of cherry, plum, nectarines and apricots. The insect is therefore of interest to the fruit-growers of Montana, though few peaches are grown. It is not probable that it will become a very serious enemy of cherries and plums, but it is thought best to include it in the list here treated.

The young larva burrows beneath the bark and sap wood during the first year of its life and passes the winter in this burrow. In the spring it resumes feeding, reaching full growth in May or June. In its hibernating condition it is liable to be transferred on nursery stock ..

It s a difficult pest to control and one that should be vigorously dealt with if it is found in Montana. Its presence on growing trees is indicated by gummy extraction from the bark at the points where its burrows touch the exterior.

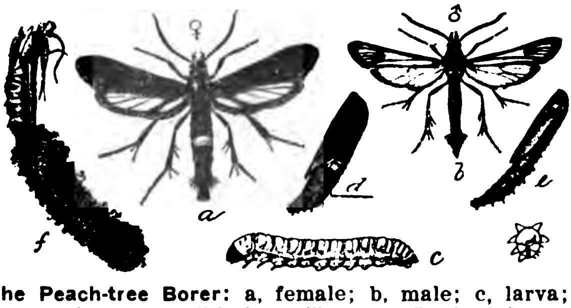

Fig. 2. The Peach-tree Borer: a, female; b, male; c, larva; d, e, female and male pupae; f, cocoon. (Marlatt, Circular 17, New Series, Div. of Entomology, U. S. Dept. of Agr.)

THE FLATHEADED APPLE-TREE BORER.

The flatheaded apple-tree borer inhabits Canada and the United States and is a native American insect. It occurs in few places in Montana and in some cases has been very destructive. Young trees during the first two years after planting are particularly liable to attack since the beetle prefers for its host trees those that have been weakened from some other cause. The hot southwestern sun in the spring of the year often "scalds" the bark on the main stem of young trees. Trees thus affected are attacked and their destruction is completed.

Various forest and shade trees are attacked as well as apple, pear and peach among fruit trees.

The female deposits her eggs in cracks and crevices of the bark in the spring and early summer. The larva hatching from the egg bores through the bark and excavates cavities of varying shape and size in the sap wood. Small trees are often girdled. The larva life lasts from one to three years and it is while in the larval burrows that the insect is liable to be distributed on nursery stock. The appearance of the insect, magnified, is shown in the accompanying figure.

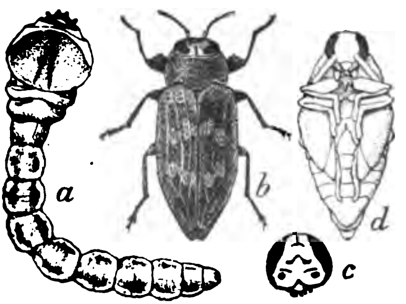

Fig. 3. **Flat-headed Apple-tree Borer:** a, larva; b, beetle; c, head of male; dk, pupa—twice natural size. (Chittenden, Circular 32, Sec. Series, Div. of Entomology U. S. Dept. of Agr.)

ROUND-HEADED APPLE-TREE BORER.

The round-headed apple-tree borer is much less frequently met with than the "flat-headed" species but its injury is more serious. Affected trees assume a sickly appearance and fail to make the proper growth. On the trunks may often be seen masses of the castings at the openings to the burrows. In some parts of the country this has been a very serious enemy to apple trees.

Besides attacking the apple it is found in various other woody plants including crabapple, quince and pear. Experience has shown that trees are very much more liable to be attacked if the trunks are surrounded by grasses, weeds or other vegetation.

The adults appear in the spring of the year and the females deposit their eggs as near to the ground as possible. The eggs hatch in about three weeks and the larvae work their way under the bark and feed for the first season in the sapwood. During the second season they feed in the deeper heartwood and in the third spring bore to near the surface where they transform to pupae the adult beetles appearing a little later. The adult is a beautiful insect measuring three fourths of an inch to an inch in length. The under surface of the body is silvery white while the upper surface is brown with two longitudinal white stripes.

This insect may be introduced into Montana in nursery stock. In looking for it the bases of the trunks should be closely examined.

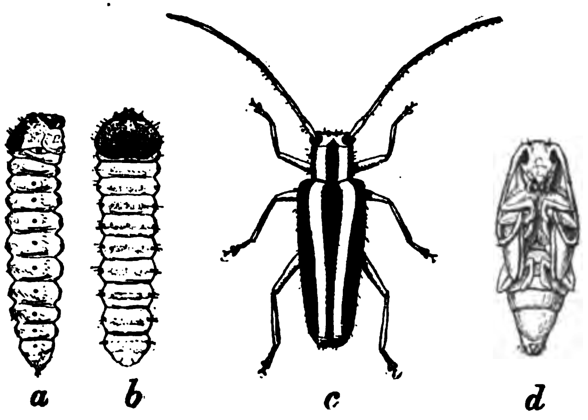

Fig. 4. Round-headed Apple-tree Borer: a, larva, from side; b, from above; c, female beetle; d, pupa; all enlarged one-third. (Marlatt, Circular 32, Sec. Series, Div. of Entomology, U. S. Dept. Agr.)

THE BRONZE APPLE-TREE BEETLE.[1]

This beetle, so far as we are informed, is confined to the Northwestern States and its economic status is not fully determined. Mr. F. H. Chittenden has given us a good account of what is known regarding the pest, in which he calls attention to various complaints regarding it from Washington and Oregon.[2] Professor C. V. Piper formerly from Pullman, Washington had sent specimens to Mr. Chittenden reporting serious damage to the apple industry of Washing ton. The same gentleman later reported that his first suspicions regarding the weevil had been much allayed by the discovery of the fact that its injuries were apparently secondary to the fungus disease known as "canker" or "blackspot".

In an orchard near Missoula an assistant, Mr. Jones, found last summer specimens which on being submitted to Dr. Howard of the Bureau of Entomology proved to be this beetle. The owner of the orchard is very jealous over the freedom of his trees from pests and has repeatedly sent this office specimens for identification. The "canker" disease has not yet been detected in his orchard though the beetle in question is fairly abundant on his trees.

These facts cannot be considered as evidence that the beetle is secondary to the fungus disease yet they point in the oposite direction. To the writer it seems possible that the fact that Prof. Piper

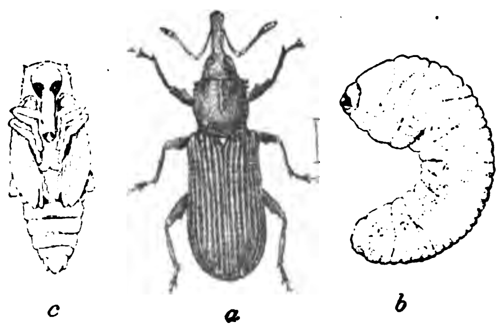

Fig. 5. The Bronze Apple Tree Borer: a, adult weevil dotted portion of size line showing length of snout; b, larva; c, pupa—six times natural size. (Chittenden, Bulletin 22, New Series, Div. of Entomology, U. S. Dept. of Agr., 1900).

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1. *Magadalis aenescens* Lec.
2. Bulletin 22, N. S. Div. Ent., U. S. D. A., page 39.

found the fungus disease and the beetle at identical spots on apple trees may be explained by the germinating spores of the fungus disease finding in the punctures into the bark made by the beetles in depositing their eggs, suitable places for gaining access to the under layers of the bark. If this be the case then the weevil is the primary cause and the fungus secondary.

Considering what information we now have regarding this borer, it is apparent that in the interests of the apple growers it will be well to watch for it and become familiar with its habits.

The beetle is small, black, and has a snout. See the accompanying figures.

Fig. 6. Work of the apple tree borer;—a, pupa in its cell; b, exterior of pupal cell; c, empty cell; d, parasitic pupa in its cell; e, two empty cells of parasite; f, beetle and holes made by beetles in their escape—all natural size. (Chittenden, Bulletin 22, New Series, Div. of Entomology, U. S. Dept. of Agr., 1900).

THE APPLE TWIG-BORER. 1.

The apple twig-borer also known as the grape cane borer is an enemy to the grape, apple, pear, peach, plum, forest and shade trees, and ornamental plants. It is especially destructive to the grape.

This has been a very common and destructive pest in the states along the Mississippi river from Iowa southward. It also occurs eastward from the Mississippi river to the coast.

In the fall and winter the adults of this insect bore into the twigs of its host plants as shown at "d" of the accompanying figure. Entering these stems the beetles hibernate there. It is thus seen

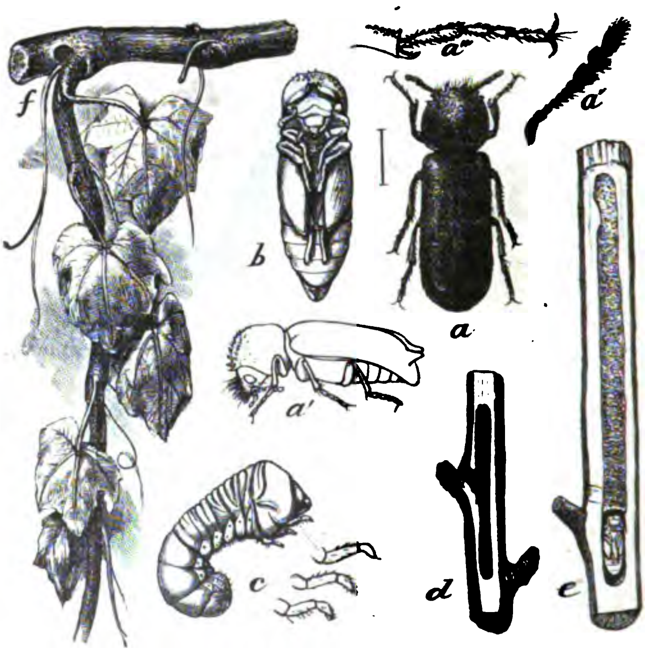

Fig. 7. The Apple Twig-borer: a, beetle, dorsal and lateral view. b, pupa from beneath; c, larva from side, with enlargements of the thoracic feet; d, burrow in apple twig made by adult; e, larval gallery in tamarisk, with pupa in cell at end; f, injury to young shoot and cane, showing the entrance to burrow of beetle near f and the characteristic wilting of the new growth—all much enlarged except d, e and f. (Marlatt, Yearbook, U. S. Dept. of Agr. 1895.)

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1. *Amphicerus bicaudatus.*

that from this fact the apple twig-borer is another pest that is particularly liable to be transferred on nursery stock. The eggs are laid in the early spring months, the beetles leaving their hibernating quarters for this purpose. The larva bores through the center of the twig until fall when it pupates later transforming to a beetle and going into hibernation as above described. There is but one brood.

The adult of the insect which is the form liable to appear on nursery stock is about ½ inch in length, cylindrical in general shape and brown in color.

THE FRUIT-TREE BARK-BEETLE.

The fruit-tree bark-beetle is an introduced insect that attacks the bark of plum, peach, cherry, and apple trees. The bark may be thickly peppered with fine holes as though by fine bird shot. See figure 9. These are the entrance and exit holes of the small beetle illustrated, greatly enlarged at Figure 8 a and b. The grubs excavate narrow galleries in various directions under the bark often killing a tree or part of its branches. The beetle usually attacks only sickly or unthrifty trees.

The adult beetles appear in the spring and begin burrowing through the bark. Upon reaching the sap wood, feeding as she goes, the female constructs, partly in the bark and partly in the wood next to it, a vertical gallery or "brood chamber", and along the sides of this at short intervals she gnaws little pockets in each one of which she deposits an egg. The very minute, whitish, grub-like larvae that hatch from these eggs excavate galleries that start out at right angles to the brood chamber. These side galleries soon

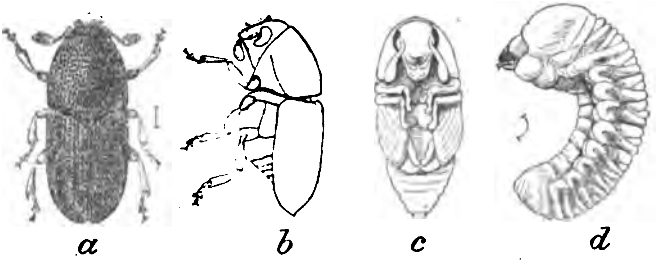

Fig. 8. **The Fruit-tree Bark-beetle:** a, adult beetle; b, same in profile; c, pupa; d, larva—all magnified about ten times. (Chittenden, Circular 29, Sec. Series, Div. of Entomology, U. S. Dept. of Agr.)

diverge, however, and increase in size as the growing larva gnaws its way away from the main burrow. Most frequently the insect lives in such numbers, with its larval galleries so closely packed together and so much confused with others that it is with difficulty that individual galleries can be distinguished.

The larvae transform to pupae at the end of their galleries. The number of generations varies in different parts of the country between one or two and four.

The species is a fairly common one in the eastern part of the United States and may appear on nursery stock shipped in for planting in Montana.

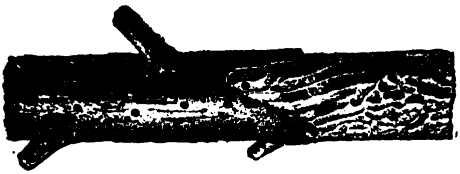

Fig. 9. Work of The Fruit Tree Bark-beetle in twig of apple—natural size. (Chittenden, Circular 29, Sec. Series, Div. of Entomology, U. S. Dept. of Agr.)

THE PEACH TWIG-BORER. 1.

In Montana markets one may occasionally find peaches containing the larvae of this insect and from its peculiar hibernating habits it is greatly facilitated in its distribution on nursery stock.

The peach twig-borer is a pest of stone fruits and is very widely distributed. From what is known of its habits it seems evident that should this pest gain access to the peach, plum, and cherry trees of this state much injury might result.

The presence of this insect on nursery stock is indicated by bits of frass attached to the bark frequently in the crotches of branches of twigs. Each of these bits of frass covers the entrance into a small burrow within which a young larva may be found. The larva at this stage is of yellowish color with the head, the top of the segment just behind it, and the posterior end of the body above, almost black. In the spring when the shoots have begun to grow the young larvae leave their hibernating quarters and bore into the

1. *Anarsia lineatella.*

tender leaf-shoots. When one leaf shoot has dried so as to become unsuitable for food another is attacked. The larva becomes full grown in about two weeks and pupates in a rather unsubstantial cocoon among withered leaves or on the surface of the bark. The moth issues in May and is very small and grayish. Two later broods occur, the larvae boring into the twigs as described or into the fruit. The larvae of this second brood construct the burrows in the bark in which to hibernate.

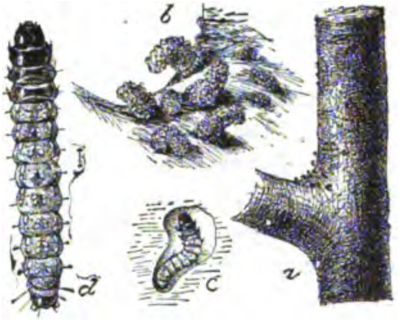

Fig. 10: **The Peach Twig-borer:** a, twig of peach, showing in crotch minute masses of chewed bark above larval chambers; b, latter much enlarged; c, a larval cell, with contained larva, much enlarged; d, dorsal view of young larva, more enlarged. (Marlatt, Farmer's Bulletin 80, U. S. Dept. of Agr., 1898.)

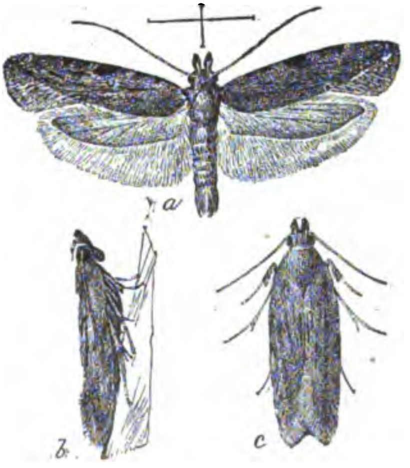

Fig. 11: **The Peach Twig-borer:** a, moth with spread wings; b and c, same with wings closed, illustrating position normally assumed—all much enlarged. (Marlatt, Farmer's Bulletin 80, U. S. Dept. of Agr., 1898.)

THE STRAWBERRY CROWN MOTH. 1.

The Strawberry crown borer is a dangerous enemy to the strawberry, blackberry, and raspberry. The adult is a member of the group known as clear winged moths on account of the transparency of the wings. They resemble wasps in their form, markings, and actions.

This species appears to be native to the United States and has been recorded by the Bureau of Entomology at Washington from California, Nevada, Colorado, and Texas.

A lady from Stevensville, Montana, made complaint of what is very likely this insect but no material could be obtained from which to make a determination of the species though an insect which was plainly a Sesiid from the manner in which it left the pupa shell protruding from the stems just above the earth. This pest had practically destroyed her entire patch of blackberries.

This again is one of the insects which is liable to be introduced on nursery stock. The partly grown larvae pass the winter in the crowns of the host plants. Just before the emergence of the moths the pupa works itself part way out through the opening previously constructed by the larva and the shell of the pupa is left at the opening when the moth departs. This is an insect that is not easy to control and its advent should be guarded against.

THE WOOLLY APHIS.

The woolly aphis is an insect much feared by fruit growers but after six years of experience in the state of Montana during which time we have learned of its presence fairly common in the state we feel warranted in saying that under the climatic conditions found here this insect will probably not be a serious pest. However, it is warrantable to watch for it and deal vigorously with it when found.

Two forms of the insect exist, an areal form feeding on the parts of a tree above the earth, and a root form feeding on the smaller roots on which they produce irregularly shaped galls.

The areal form often attacks partly healed wounds in the bark.

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1 *Sesia rutilans* H. Edw.

The bodies of this form are covered by a white flocculent matter, and when several of the insects are huddled together as is usually the case with this louse, the white blotches become conspicous objects.

The insects' most natural means of wide dissemination is on the roots of apple trees intended for planting.

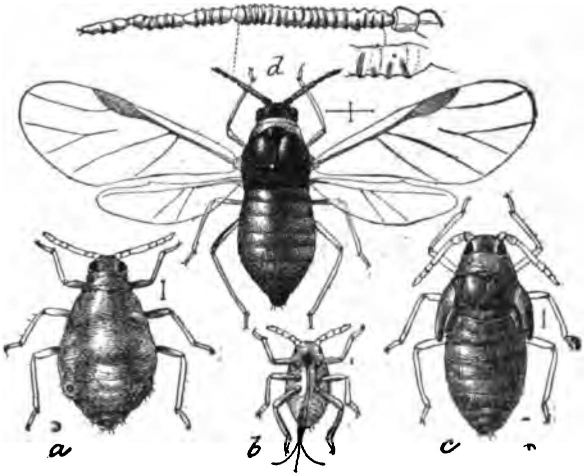

Fig. 12. **Woolly aphis: a, agamic female; b, larval louse; c, pupa; d, winged female with antenna enlarged above; all greatly enlarged and with waxy excretion removed. (Marlatt, Circular 20, Sec. Series, Div. of Entomology, U. S. Dept. of Agr.)**

THE SAN JOSE SCALE.

The San Jose scale is an oriental insect but it was first noticed in literature from the town in California from which it took its name. It is now of world wide distribution and has been the cause of much loss and expense. Of small size and insignificant appearance but very tenacious of life and endowed with great powers of multiplication, it has been an enormous factor in the fruit growing and nursery businesses.

The San Jose scale is a general feeder, attacking nearly every variety of decidous fruit trees. In the east it has done its principal damage to peach and pear but its full list of food plants includes many ornamental plants and shade trees.

It passes the winter as a partly grown female. In the spring young are produced which wander off and finding suitable places on

the plant settle down and begin feeding. Other broods follow, the number varying with the latitude.

The female scale is circular about one-twelfth of an inch in diameter when full grown and only slightly convex. It is gray or blackish sometimes with a yellowish tinge.

The mature male is oblong-oral, its length being about one-half the diameter of the female scale, black or grayish and having in the center a nipple-like prominence. See the accompanying figure.

It is a source of wonder to many that an insect so small as the San Jose scale can overcome a tree. The explanation is found in the fact that the life of the tree exists just under the bark upon which the countless numbers of scales settle inserting their beaks into the vital tissues just under the surface. While these insects

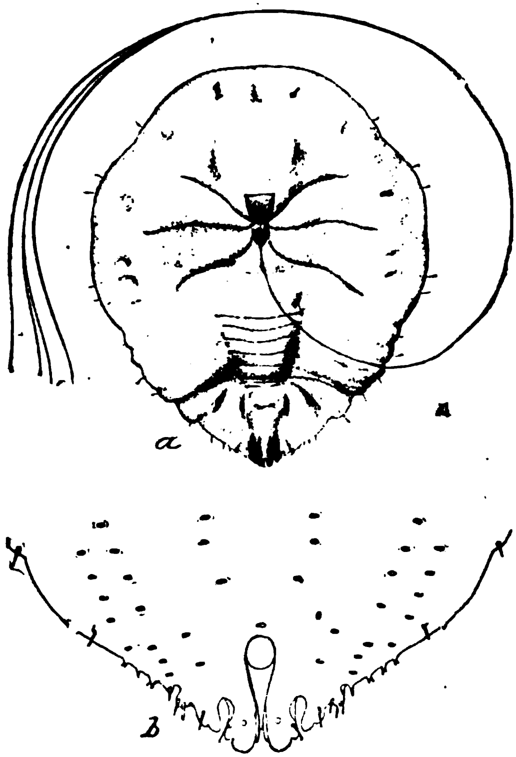

Fig. 13. San Jose Scale: a, adult female showing very long sucking setae; b, anal plate showing characteristic ornamentation of edge; greatly enlarged. (Howard and Marlatt, Bulletin 3, Div. of Entomology, U. S. Dept. of Agr.)

may not kill a tree outright they may so blight it as to render it useless.

The question is often asked: "Would the San Jose scale become a serious pest in the latitude and under the climatic conditions of Montana"? While there is room for a reasonable doubt that this scale would be a serious menace to Montana fruit trees, the fruit growers should keep the benefit of the doubt on their side and urge the enforcement of the laws that are intended to prevent its admittance and should watch for, and if possible, suppress it as it comes.

It is true that in localities where it thrives methods are now devised whereby it may be held in control but the application of these means is expensive and the presence of the pest is a cause of anxiety to the owner of the infested premises.

a b

Fig. 14. San Jose Scale: a, infested twig natural size; b, as the scales appear under a hand lens. (Howard and Marlatt, Bulletin 3, New Series, Div. of Entomology, U. S. Dept. of Agr.)

PUTNAM'S SCALE INSECT. 1.

Putnam's scale insect is widely distributed and feeds on all orchard trees. It is similar to the San Jose scale in general appearance but it may be easily distinguished from that species by the orange colored spot (the exeuvia) on the scale of this species and the less circular outline.

This insect is single brooded. It passes the winter in a nearly full grown condition. The young begin to hatch in July and continue during the month.

Putnam's scale has been taken by the writer near Missoula in an old orchard and on an old neglected tree in the city of Missoula.

THE GREEDY SCALE INSECT. 2.

Smith cider and other varieties of apples coming into the Montana market from California occasionally bear specimens of this scale insect. We have seen apples with many specimens of this species crowded in at the blossom and stem ends. It is not a species that could survive our climate and need not be feared as a pest on apples in Montana. It is common in greenhouses where it reproduces in great numbers.

The scale is gray in color but somewhat transparent so that when covering the yellow body of the living female the scale has a yellowish tinge. When removed from the bark or fruit a white scar is left.

The adult female scale is very convex and among scale insects is conspicious for this characteristic.

It is widely distributed in the United States and is without much doubt an introduced species.

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1. *Aspidiotus ancylus* Putn.
2. *Aspidiotus camelliae* Boisd.

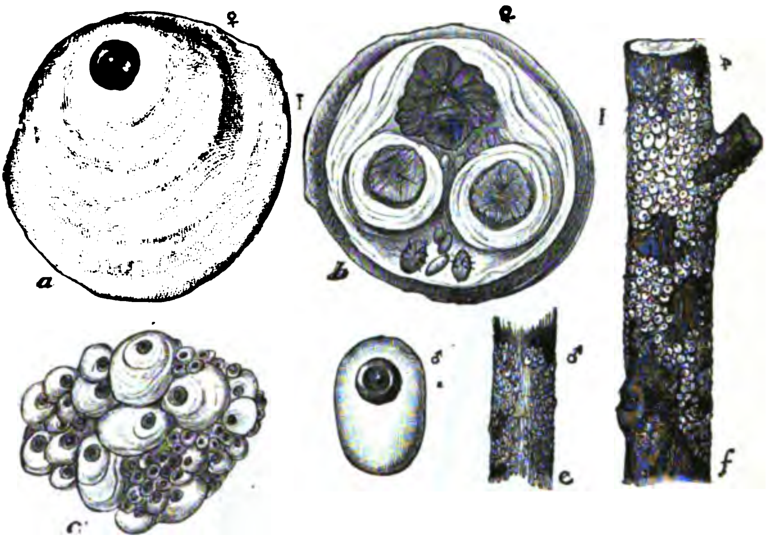


Fig. 15. **The Greedy Scale Insect:** a, female scale from above; b, same from below; c, mass of scales as appearing on bark; d, male scale; e, male scales on twig; f, female scales on twig; e and f, natural size; c, considerably enlarged; a, b, d, greatly enlarged. (Howard, Yearbook, U. S. Dept. of Agr., 1894.)

THE OYSTER-SHELL BARK LOUSE.

The oyster-shell bark louse is the best known of any of the orchard scales. It probobly came originally from Europe but it is now known throughout the world. Like the other scale insects here discussed it is particularly adapted to distribution on nursery stock.

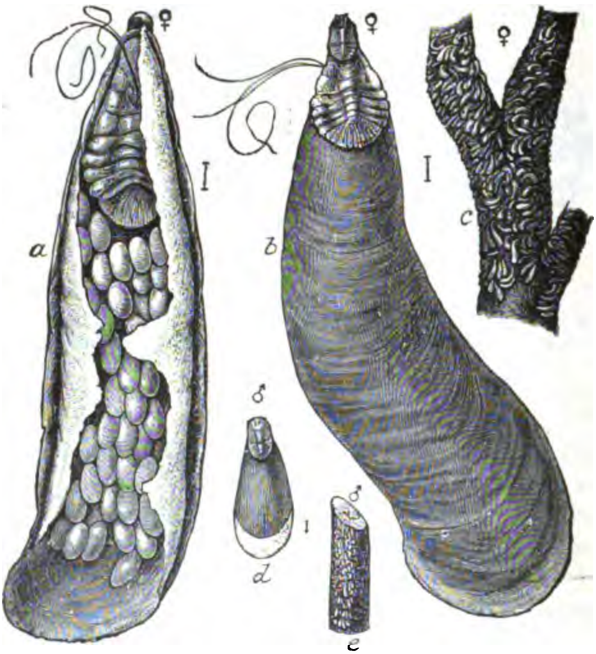
This insect attacks a variety of food plants including apple, pear, plum, quince, hawthorn, raspberrq, currant, linden, willow, cottonwood, poplar, wild cherry, rose, lilac , and white birch. Many of these it attacks so severly as to threaten their lives.

The scales of the two sexes are quite different in size and appearance. The female scale is elongated (see "a" of the figure) rounded on the upper surface, flat beneath, and brownish in color. The male scale is much smaller but of the same color.

If one of the female scales be turned over during the winter there may be seen numerous very minute white eggs closely packed

together. With the awakening of nature in the spring these eggs hatch into minute whitish larvae which crawl out from under the parent scale and go to suitable spots for settling down. These larvae go mainly to the tender new growth. In the North there is but one brood but farther south there are two.

This scale insect is present in a few localities in the state and has been very prolific and troublesome.



eggs; b, same from above, greatly enlarged; c, female scales; d, male scales, natural size. (Howard, Year-book, U. S. Dept. of Agr.)
Fig. 16. Oyster-shell Bark-louse: a, female scale from below showing

THE SCURFY BARK LOUSE.

The scurfy bark louse is an elongated insect similar in shape to the oyster shell bark louse but the substance of the scale is thinner in texture and white in color. (See the accompanying figure).

The winter it passes as eggs closely packed under the scale. The eggs number from thirty to seventy-five and are of a reddish purple color. In the climate of northern United States there is but one brood. The eggs hatch in the spring and by fall the life cycle, which is similar to that of the oyster shell louse, is completed.

This species is not very liable to be introduced on nursery stock. The white color of the scales renders them conspicuous objects and the nurseryman who desires his trees to have a clean healthy appearance will usually notice them and remove them before shipping. The oyster shell bark louse, on the other hand, is not noticeable, its color being similar to that of the bark.

Fig. 17. Skurfy bark-louse: a, c, females; b, d, males;a, b, natural size; c, d, enlarged. (Howard, Year-book, U. S. Dept. of Agr.)

OTHER SCALE INSECTS.

There are a few other scale insects that might be discussed in this paper but which are not liable to often appear on nursery stock arriving in Montana.

Scale insects are not easily identified except by the expert, and much may depend on the identity of a scale that is found in an orchard or nursery. The Experiment Station will gladly make determinations of scale insects or any others that are sent in.

THE CODLING MOTH OR APPLE WORM.

The well known apple worm is enormously destructive to apples and pears in the United States. It is said to destroy, on an average, about one half of the apple crop of the United States annually. Its injuriousness is much less in Montana than in some other states where the climatic conditions are more favorable to it but we believe that the percentage of damage under ordinary conditions will vary from about 15 to about 55 when nothing is done to hold it in check. The apple is Montana's most successful fruit and the codling moth its worst insect enemy.

The codling moth is two-brooded in Montana. The first eggs of the season are laid about the middle of June. By the latter part of July wormy apples become noticeable. The second brood begins its operations about the 10th to the 15th of August and is principally injurious to fall and winter varieties.

It occurs in a few isolated localities in the following counties: Flathead, Sanders, Missoula, Ravalli, Broadwater, Yellowstone, and Custer.

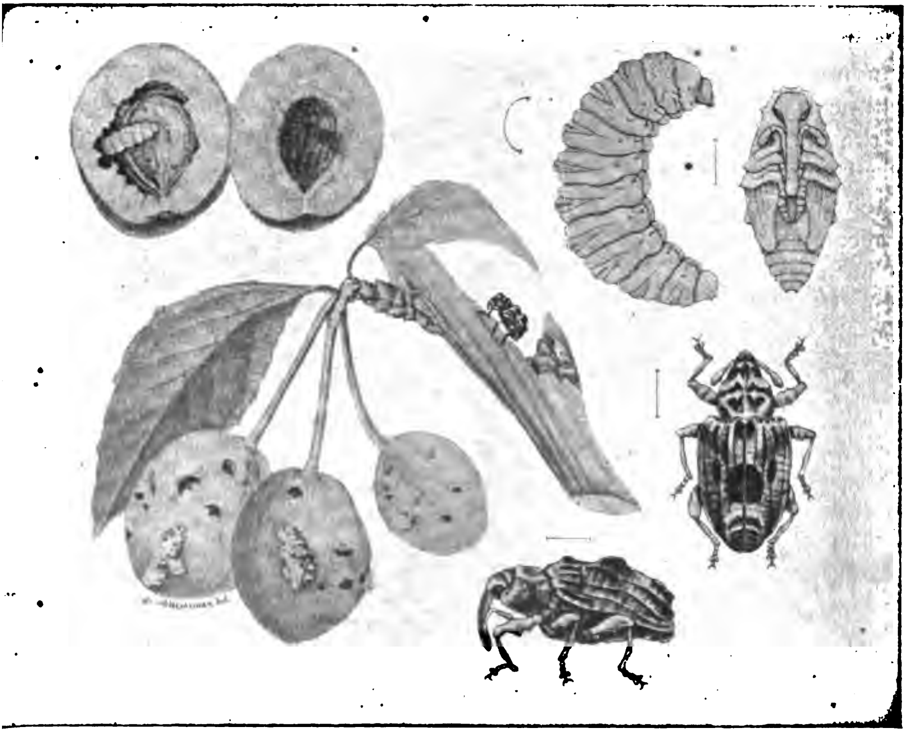
For means of wide distribution the codling moth is mainly dependent on traffic in fruits. It has extended itself throughout practically the whole world and is believed to have done so almost entirely through the medium of fruit packages. It is a particularly dangerous practice to carry second hand fruit boxes into the orchard to be filled again. This practice is now prohibited by law.

Fruit growers should heartily co-operate with the state authorities in the campaign against this pernicious insect.

THE PLUM CURCULIO.

The plum curculio is a serious enemy to stone fruits and is partial to plums. The accompanying illustration shows its method of injuring plums. It is an insect pest of first class importance and has in some sections practically killed the industry of plum growing. Besides attacking the plum it breeds in great number in cherries, peaches, appricots, nectarines, quinces, apples, crabs, and haws.

Its means of distribution is principally in the larval stage through



18. The Plum Curculio, (Lugger).

the medium of crated cherries shipped from one locality to another. It hibernates as an adult and may be distributed in this stage.

Its presence may be detected by the characteristic cresentic slits that it makes on the young fruits that it attacks and by the grub in the fruit. However, there are other insects that feed in stone fruits.

This is a native American insect. It is said to occur near Stevensville, Montana, and in Yellowstone County.

TENT CATERPILLARS.

There are about five species of tent caterpillars that are liable to be found in Montana. We have already had a few complaints of these insects and the writer saw a nest of what was probably the common eastern species, (*Clisiocampa americana*) in Missoula county. Within certain limits the caterpillars of all these species appear alike and the accompanying illustration will give a reliable idea of the general appearance.

The winter is passed in the egg stage. The egg clusters shown in the accompanying figure are liable to occur on any bill of nursery

Fig. 19. Clisiocampa americana: top view of full grown caterpillar. (Lowe, Bulletin 152, N. Y. Agl. Exp. Sta.)

stock. One would not be warranted in rejecting the shipment or burning it. The egg clusters are easily removed, or if they escape detection and hatch in the trees after they are set out, the nests are conspicuous and easily destroyed. There is little excuse for allowing this insect to continue in an orchard year after year. The nests may be removed caterpillars and all without injury to the trees. Wild cherry trees in the vicinity of the orchard should be kept free from the nests so as to prevent infection of the fruit trees.

The caterpillars hatch from the eggs early in the spring and congregate in a forked limb or branch and spin a nest or "tent". This is their home from which they migrate for the purpose of feeding.

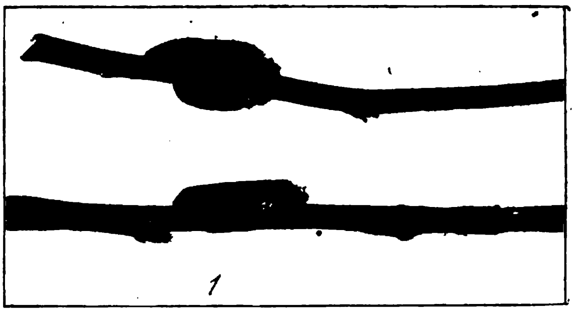


Fig. 20. Egg masses of Clisiocampia americana. (Lowe, Bulletin 152, N. Y. Agr. Exp. Sta.)

THE BUD MOTH. 1.

The bud moth is a small, brownish, hairless, black headed caterpillar about ¼ of an inch long which feed in the buds of apple and pear in the spring of the year, and after the buds have expanded,

1. *Tmetocera ocellana.*

on the leaf and flower buds which they destroy. Later in the season the new brood feeds on the epidermis of the leaves. The injuries from the species are due to the destruction of the fruit buds and to the deformities induced by the eating off of terminal buds.

The adult is a moth somewhat resembling the codling moth. The eggs are laid on the foliage about the first of July. The winter is passed as a partly grown larva in a hibernaculum constructed for the purpose. These hibernacula are very difficult for an inspector to detect and the insect is one that may readily be distributed on nursery stock, scions, etc.

The bud moth has been periodically injurious in the East. In another part of this report are notes on the life-history and means of controlling its ravages.

The species occurs at Missoula where it has been very injurious. I have also found it on a few trees twelve miles up the Bitter Root Valley and for a short distance up the Rattlesnake Valley.

A reasonably complete account of this insect was given in the First Annual Report of the State Entomologist, (1903).

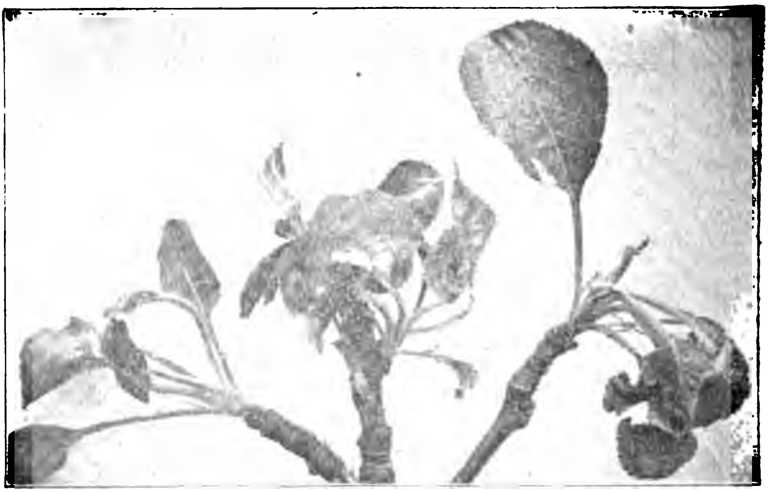


Fig. 27. Work done by bud moth larvae early in season on apple twig. (Slingerland, Bulletin 147, Corn. Univ. Experiment Station.)

THE PEAR AND CHERRY SLUG.

The larvae or slugs of this insect feed on the upper surface of the leaves leaving a network of veins and the lower cell layers. The leaves so affected turn brown, die and drop off. Whole trees or whole orchards may be thus defoliated. A second growth may be put out thereby weakening the tree so that no fruit is produced the next season. In the early spring the adults may be seen about the treeswhere they gather for the purpose of laying their eggs. The larvae soon hatch and feed on the leaves. They are at first white, but they soon have a shiny olive colored fluid on their bodies.

The insects feed on pear, cherry, and plum and about thirty other plants. It shows a preference for pear.

The species occurs throughout Europe and America and in many of the British colonies.

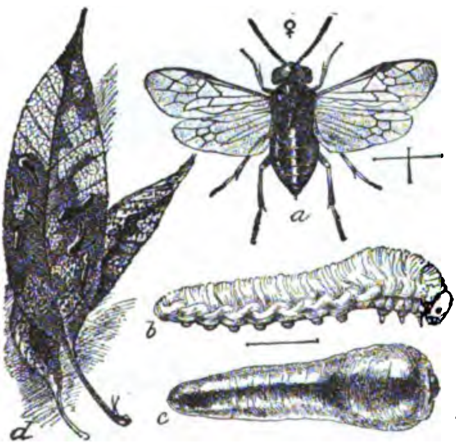


Fig. 22. Pear and Cherry Slug: a, adult saw-fly, female; b, larva with slime removed; c, same in normal state; d, leaves with larvae, natural size; a, b, c. much enlarged. (Marlatt, Circular 26, Sec. Series, Div. of Entomology, U. S. Dept. of Agr.)

THE PEAR-LEAF BLISTER-MITE.

The pear-leaf blister-mite is another pest that is particularly liable to be distributed on nursery stock, scions, etc. The almost microscopic mites hibernate under the scales of the buds and their detection through inspection is out of the question.

In the spring as the young, tender leaves are being put forth the over-wintered mites pass to the under side of the leaves and produce whitish or reddish blisters under which they later produce young which migrate and cause new blisters.

The pest is severe on individual trees but does not spread rapidly. Over short distances the young might be carried on the feet of birds or might be blown with the fallen leaves late in the season.

The blisters, often highly colored and usually arranged in rows parallel with the mid rib, one row on each side, are characteristic. This pest occurs in some of the fruit growing regions of Montana.

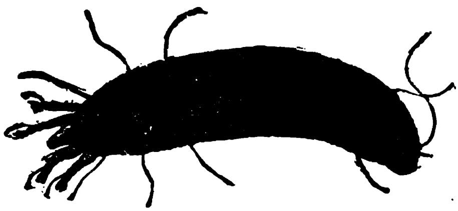


Fig. 23. **The Pear-leaf Blister-mite:** greatly enlarged. (Comstock, Manual for the Study of Insects, 1897.)

THE STRAWBERRY LEAF-ROLLER. 1.

The strawberry leaf-roller is a fairly well known pest in some parts of the United States. In the state of Washington it has been looked upon as their most serious insect enemy of strawberries. Though it has been in Montana for a number of years we have no record of great injury from it.. It occurs at Missoula, Helena, and Miles City. It receives its name from its habit of rolling and crumpling the leaves of its host-plants. The larva which is small

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1. *Phoxopteris comptana* Frol.

and of a greenish color lives within the rolled or crumpled leaves feeding from the inside. When abundant, the larvae not only eat parts of the foliage but cause the remainder to turn brown. The larvae are very active and when taken into one's hand quickly wriggle out and drop to the ground.

There are two broods, one appearing in June and the other in August.

The larvae feed on the foliage of strawberry, raspberry, blackberry and various other plants.

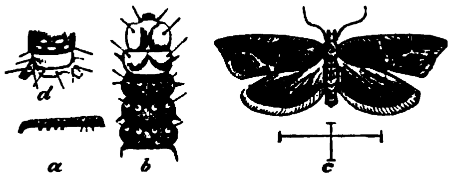

Fig. 24. **The Strawberry Leaf-roller: a, larva, natural size; b, anterior end of larva, seen from above, enlarged; c, moth, enlarged; d, posterior end of larva, seen from above, enlarged. (First Rept. Insects of Mo., Riley, 1869.)**

THE CHERRY FRUIT-FLY. 1.

The plum curculio is responsible for most "wormy" cherries but "cherry fruit-fly" may appear in the market fruits and if in the market is liable to escape to growing cherries. The cherry fruit fly as its name indicates is a fly and it is the larva or maggot that causes the damage. The work of the grub of the plum curculio is usually apparent from the exterior of the cherry, but in the case of this maggot the cherries may from the outside appear to be perfectly sound.

The cherry maggots are very light yellow in color and of the shape and size shown in the small black circle, above, in the accompanying figure.

The body of the fly is black and the head and legs are of a light yellow color. The wings are crossed by four blackish bands and have a blackish spot at the tip.

This insect is not very well known as a pest of cherries. It has been reported only from the eastern states. It is, however, one of

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1. *Rhagoletis cingulata* Loew.

the insects that our Montana cherry growers should be on the look-out for.

The winter is passed by the immature insect in the ground. If this pest becomes established in Montana it will most likely be through the introduction of infested cherries. Wormy cherries rejected from those pitted for canning and thrown out on the refuse pile would furnish all the necessary conditions for the infection of any cherry trees in the vicinity that might be in bearing the next season.

Fig. 25. The Cherry Fruit-fly: Section of a cherry, enlarged to show the maggot and the nature of its work. The small figures above show the maggot and its parent, the fruit-fly, natural size. (Slingerland, Bull. 172, Cornell Univ. Exp. Sta., 1899.)

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MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

F. B. LINFIELD, DIRECTOR

BULLETIN NO. 56

NATIVE ECONOMIC PLANTS OF MONTANA

BY

J. W. BLANKINSHIP
Botanist

BOZEMAN, MONTANA
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THE NATIVE ECONOMIC PLANTS OF MONTANA.

J. W. BLANKINSHIP, *Botanist.*

PREFACE.

One of the characteristics of an uncivilized, nomadic people is to secure food and sustenance from a great variety of plants native to the region inhabited, while a civilized, agricultural people depend upon a relatively few domesticated species to meet their wants. Neverless, in the complex activities of modern life there is an increasing tendency to make every department of Nature contribute to our comfort and welfare, and this is evident in our efforts, not only to improve the present varieties of plants under cultivation, but to seek in foreign lands for new species, which may be so improved by cultivation that they will supply new wants or supplement those plants already in use. It therefore, is of importance to seek out these primitive races and ascertain the plants which they have found available in their economic life, in order that perchance the valuable properties they have utilized in their household economy, may thus fill some vacant niche in our own, or at least prove of value in times of need.

The object of this paper is, therefore, to enumerate, as far as possible, the native plants of the state utilized by the Indians, the early explorers, trappers and settlers, as well as to mention the chief species now employed in our own industrial life. This is now the more necessary because of the fact that the pressure of settlement will no longer permit the occupation of large and valuable tracts of land as practical game preserves by a relatively few individuals of the primitive inhabitants and because the new conditions are compelling the Indians to abandon their tribal organization and to adopt the ways of the white man in order to avoid extinction, so that in a ew generations, under these new conditions of life, all knowledge of the properties of our native plants acquired by them through long ages of stress of famine, of climate and of tribal warfare will be lost and can hereafter be secured only by long experimentation. It therefore behooves the botanist in these western states, where the Indian yet retains somewhat of his primitive habits and many of the men active in the early settlement of the country

are still alive, to secure this information and make it available for future use.

In the preparation of this paper I have endeavored to collate all the data available in the published accounts of the early explorers and settlers of the state, supplemented, as far as possible by my own observations on the several reservations within our limits. Yet, I can hardly claim for this more than a preliminary study of the subject, for a great mass of data yet awaits the careful investigator acquainted with the flora of the region studied. In particular the native "medicine men" possess a vast deal of information as to the medical properties of our native plants, which can now be easily secured, but in the near future will be utterly lost to science, unless prompt action be taken.

Little has been said in the present paper as to the methods of cookery of the Indians, as the subject is one that should be undertaken by someone well versed in the culinary art; yet, it seems probable that these rude children of nature with their crude methods and paucity of materials were able in some cases to obtain results and secure flavors, which we with all the complex appliances of modern civilization, can hardly attain. This phase of the subject of ethnobotany should not be neglected, for in the humblest fields of scientific endeavor are sometimes discovered facts of the greatest importance.

The plants mentioned are arranged alphabetically by their scientific names with an index of common names at the end, where there will also be found a general classification of the species by their uses. In the citations the name of the author is given with the page where the species is mentioned. The full titles of the works quoted are given under the "bibliography" on pages 28-30.

I am indebted to the library of Harvard University for the use of the various works consulted and under many and deep obligations to the Indian Agents of the various reservations and to many others who have actively assisted me in securing the information for this work.

Finally, I request the citizens of the state to send me specimens of plants thus utilized by the Indians and early settlers or employed for present use, which are not mentioned in the following lists in order that the species may be determined and their properties noted.

Bozeman, Montana, September 30, 1905.

Abies lasiocarpa, Nutt. "Balsam Fir"; "Alpine Fir".

The "balsam" or gummy secretion found in the blisters on the bark of this species is highly esteemed as an antiseptic for application to wounds and ulcers and is taken internally for lung troubles. The young twigs and leaves are burned for incense by the Crow Indians (Absaroka) in certain ceremonies. The application of the balsam to corns for a few days is said to render them easily removable by soaking in warm water.

Acer glabrum, Torr. "Shrub Maple"; "Mountain Maple".

The young twigs were used by the Indians for making hoops for fishnets.—Douglas, 102.

Achillea lanulosa, Nutt.

A tea made of the herb used by the Indians as a cathartic.

Achillea millefolium, L. "Wild Tansy"; "Milfoil".

Tea of the leaves and flowers is used for consumption, stomach-trouble and headache and applied as a lotion for sore eyes and for sprains and bruises.—Chesnut, 391.

Acorus Calamus, L. "Calamus Root."

Still an object of barter among the various Indian tribes and said by the Ft. Peck Sioux to be used to cause abortion. Also used by them as a sort of cure-all; they chew and swallow the root. The plant is not found in Montana, but is obtained from the Indians eastward.

Agropyron occidentale, Scribn. "Blue-stem grass."

This with other species of Agropyron is the most valuable forage grass in the lowlands and is the chief component of the wild hay so extensively cut in the state. It is now cultivated for haylands throughout the Milk River region and promises to become the most important forage grass for the arid regions, where irrigation is deficient. It is said to have better keeping qualities and a higher nutritive value as a stock food than timothy, clover or alfalfa.

Alectoria Fremontii, Tuckerm. "Black Moss"; "Tree Moss."

A long, black, hair-like lichen common on various species of Conifers in the mountains, used by the Indians as a famine food. Cattle said to be "poisoned" by feeding upon it to excess in early spring. Said to be neither palatable nor very nutritious.—De Smet, 117; Dodge, 424; Coville, 87.

Allium species. "Wild Onions"; "Garlic".
Cooked and eaten by the various tribes.—De Smet, 116.

Alnus tenuifolia, Nutt. "Alder".
A decoction of the inner bark used by the Indians as an orange dye.—Coville, 94. The bark is said to have been used in some cases in Montana for the purpose of tanning and to have given good results.

Amaranthus blitoides, Wats. "'Pursely".
Said to be used as a pot-herb. The seeds of this and other species were formerly an article of diet among the Indians.

Amelanchier alnifolia, Nutt. "Sarvice Berry"; "Tee-amp" (Snake Ind.)
An important food plant among all tribes. "The Indians gather and dry them in large quantities for winter use. The wood is very hard and tough, and is much used by the Indians, who are expert in straightening it for arrows and ramrods".—Stuart: Montana As it Is, 86. See also Dodge, 413; Catlin: 1:122. The berries are found frequently in our markets during the season and are used for pies, much as the blueberries are in the East; they are usually mixed with currants, gooseberries or rhubarb, to lend acidity to the combination. They are also put up spiced, are used for wine and made into jam with other fruits.

Ampelopsis quinquefolia, Michx. "Virginia Creeper".
The ripe fruit is collected and eaten, like grapes, by the Sioux.

Aphyllon fasciculatum, Gray. "Cancer Root."
A frequent parasite on the roots of Artemisia frigida, Willd. and popularly thought to be a remedy for cancer. Reported poisonous to stock.

Apocynum androsæmifolium, L. "Indian Hemp".
The fibre made from the bark of this and *A. cannabinum*, L., furnished the chief source of cordage among the western Aborigines. See Douglas 90, 102 & 121; Chickering: Hayden Survey, 1878: 821; Chesnut, 379. The root is used by the old settlers as a tonic, febrifuge and cathartic, but is poisonous in large doses. Cattle are sometimes said to be poisoned by feeding on it.

Aralia nudicaulis, L. "Sarsaparilla"; "Ginseng".

Frequent in the forests west of the Divide and its roots are used as a tonic and cathartic.

Arctostaphylos Uva-ursi, Spreng. "Larb"; "Kinnikinnink"; "Timiyah" (Snake Ind.); "Sacacomis".

The leaves are mixed with tobacco for smoking by all the Indian tribes and the fruit is used for food both fresh and dried.

Artemisia cana, Pursh. "Blue Sage"; "Sage Brush".

A decoction of the leaves used by the Indians for various complaints. Used as a general tonic. Said to have been employed successfully as a hair-restorer. The leaves were sometimes chewed to allay thirst.

Artemisia frigida, Willd. "Sweet Sage"; "Old-man".

A decoction used by the Indians as a remedy for lung troubles.

Artemisia tridentata, Nutt. "Sage-brush".

The dead twigs were used by some tribes for a twirling-stick in fire-making. "A decotion of the herbage is used internally to check diarrhoea, externally as an eye-wash, while the mashed herbage is used as a subsitute for liniment."—Coville, 105.

Asclepias speciosa, Torr. "Milkweed"; "Silkweed"; "Butterfly Weed".

The Crow Indians boil the flowers for food and eat the raw seeds in the young, immature follicles, while the "milk" from the broken stems has been used in cases of emergency for branding stock temporarily, the points of application turning dark and remaining so for several months.

Astragalus caryocarpus, Ker. "Ground Plums:" "Indian Pea".

The fleshy, plum-like pods have a sweetish insipid taste and were eaten by the various tribes of Indians in July both raw and boiled. Now occasionally used for pickles.

Balsamorrhiza incana, Nutt.

"The thick roots are eaten by the Nez Perces Indians without previous cooking."—Dodge 406.

Balsamorrihiza sagittata, Nutt. "Bigroot;" "Arrow-leaf."

The roots are used for food, both raw and cooked. They are "fermented a day or two in the ground in a hole made for the purpose, and heated with hot stones, are then eaten and possess an agreeable saccharine taste."—Nuttall, Jour. Acad. Phila. 7:39. The young stems and leaves are eaten raw as a salad and the seeds are roasted and ground into a kind of flour.—Coville 106; Dodge, 406; Meehan, Proc. Phila. Acad. 1898:32.

Bazzania trilobata (L.) S. F. Gray.

"Used by the natives as a yellow dye; grows on the pines of the Rocky Mountains".—Lewis label. Meehan, 47.

Beckmannia erucæformis, Host. "Slough-grass".

Seed sometimes used for food by the Indians.—Coville 91.

Berberis repens, Lindl. "Oregon Grape".

A decoction of the bark of this root is used as a remedy for mountain fever and by the early settlers for kidney trouble; also used for stomach trouble and as a tonic and febrifuge. The ripe fruit is strongly acid and is used as an article of food both raw and made into jelly; it is used also for wine and is sometimes crushed and mixed with sugar and water for "lemonade".

Betula papyrifera, Marsh. "White or Paper Birch".

The bark was used by the Indians to make their "birch-bark" canoes and is still used by the Flatheads to line sacks and stiffen them into baskets.

Bouteloua oligostachya, Torr. "Buffalo or Grama Grass".

The Indians use it to foretell the winter; they say if the culm has but one fruit-spike the winter will be mild, if two or more the winter will be correspondingly severe. Probably the most important forage grass in the state.

Calochortus species. "Mariposa Lily"; "Sego Lily".

The bulbs of the various species found in the state were dug and eaten by the Indians and are said to be of a pleasant flavor.

Calvatia gigantea, Batsch. and other mushrooms.

The dry, powdery interior is used by the Sioux to place in large wounds as a styptic to stop the bleeding.

Camassia esculenta, Lindl. "Camas"; "Biscuit-root".

Formerly a very important article of diet among all the tribes. The plants usually grow in low open meadows in the mountain valleys, often in great abundance and here the Indians would journey in the "camas season" to lay up their store for winter use. The bulbs were dug about the time when the flowers on the lower half of the raceme began to fade, or after it was past blooming, though in the latter state it was not so easy to see the plants. The bulbs were then baked in the ground by hot stones and dried for winter use. The baking greatly improved the taste. The camas was also boiled for eating fresh or preserved and was said to have a sweet, gummy taste and to be very nutritious. The Flatheads called it "Etwoi" and the Snakes "Paseego".

Carex species. "Sedge."

The leaves were woven into mats and the succulent stems of some species were used for food when young.—Coville, 92 and others.

Carum Gairdneri, Benth & Hook. "Yamp"; "Squaw Root".

A tall slender, parsnip-like plant common in mountain meadows. The root consists of one or more fleshy, tuber-like roots, often as large as the thumb and these were collected and boiled by the Indians like potatoes. They were said to have a cream-like flavor.

Cercocarpus ledifolius, Nutt. "Mountain Mahogany."

A shrub ten or fifteen feet high, common in some parts of the mountains. The wood is extremely hard and enduring and was used by the Indians for making "camas sticks" and for the heads of fish spears.—Coville, 93 and 98.

Chenopodium album, L.

The seeds were gathered by the Indians for food, which may account in part for its wide distribution and abundance in the state, as is probably the case with the sunflower (Helianthus annuus, L.) and the horseweed (Iva xanthiifolia, Nutt.). The seeds were ground into flour and made into bread. The young plants are also used by Indians and whites as a pot-herb.

Chimaphila umbellata, Nutt. "Prince's Pine."

A decoction of the herb or root used as a febrifuge to reduce fevers.

Cicuta occidentalis, Greene. "Water Hemlock"; Water Parsnip"

The fleshy roots were known to the Indians as a virulent poison and sometimes used by them for suicide.

Claytonia multicaulis, Nelson and **C. lanceolata,** Pursh. "Ground Nut;" "Spring-beauty."

A small plant some four inches high with white or pinkish flowers and a tuber-like root, common in the mountains in early spring. These roots were dug and eaten by the Indians both raw and roasted Douglas, 109. They are said to be "insipid," but are very nutritious, as they have been recently reported as "better for fattening hogs than the best feed" (J. F. Bean, Dupuyer, Mont.).

Clematis Douglasii, Hook. "Headache-weed"; "Lion's Beard".

A decoction of the leaves of this species is used by the Indians as a remedy for the headache. Geyer says (London Jour. Bot. 5: 301): "The Indians use the root of this plant as a stimulant, when horses fall down during their excessive races. They hold a scraped end of the root into the nostrils of the fallen horse. The effect of this is instantaneous; it produces trembling, the animal springs up and is led to water to refresh its limbs. I have been told it never failed or produced bad consequences. The scraped root leaves a burning sensation for half a day, if touched with the tongue."

Clematis lugusticifolia, Nutt. "Wild Clematis;" "Virgin's Bower."

Chewed for the purpose of curing colds and sore throat.—Chesnut, 347. Often grown as an ornamental vine for houses and verandas.

Cnicus eriocephalus, Gray. "Mountain Thistle;" "Thistle-root."

Called by the Snakes "Tsinah". "The root of the common thistle, which is very abundant in the bottoms along nearly all the streams in the mountains; they grow to about the size of a large radish, and taste very much like turnips, and are good either raw or cooked with meat; they are only good, however, during the months of March and April, as after that time they become pithy. They are much used by the Indians, who also eat the young and succulent stalks during the months of June, July and August, on the same principle that white folks eat asparagus and greens."—Stuart, 96.

Cornus stolonifera, Michx. "Red Willow"; "Kinnikinnink".

The "Bois rouge" of the Voyageurs. The inner bark was scraped off by the Indians, dried and mixed with tobacco in the proportion of threeto one under the name of "kinnikinnink," as ssubstitute for the "larb" (Arctostaphylos Uva-ursi, Spreng.) of the mountains. Fish-nets were made of the twisted branches and a decoction of the bark was used as a wash for ulcers.—Hayden, Rep. Sec. War, 1858, 2:736, 739; Geyer, 290; Hooker, Lond. Jour. Bot. 6:237.

Crataegus Columbiana, Howell, and **C. Douglasii,** L. "Red Haw," "Black Haw."

"The fruit is eaten fresh and mixed with choke-cherries and service berries, which are bruised, then pressed into cakes and dried for winter use."—Dodge, 413. The wood was used for making "camas sticks" for digging these and other roots. These sticks were about two feet long, curved like a saber and provided with a crosspiece of elk-horn cn the top to serve as a handle. "This instrument they used with astonishing dexterity, so that they seldom strike the point twice after the same bulb."—Geyer, 300. Fruit called ."Stlak" by the Flathead Indians.

Echinacea angustifolia, DC. "Rattlesnake Weed;" "Snake-root."

The root formerly used extensively by the Indians and traders as an antidote for the bite of the rattlesnake.—Hayden, 738. Even the dried root has a smarting, acrid taste and causes a profuse flow of saliva.

Elæagnus argentea, Pursh. "Silver-bush."

The fruit is edible and was an article of diet among the Indians. Newberry, Pop. Sci. Month. 32:45.

Elymus condensatus, Presl. "Rye-grass;" "Buffalo Rye."

The seeds were used for food by the Indians.—Coville, 91. Promises to be a valuable source of ergot.

Ericooma cuspidata, Nutt. "Indian Millet;" "Wild Rice."

The seeds were gathered and used for food by the Indians. Not rare in dry sandy places eastward.

Erythronium grandiflorum, Pursh. "Dog-tooth Violet."

The bulb-like roots were eaten to some extent by the Indians and were crushed and made into poultices for boils.—Chesnut, 326.

Evernia vulpina (L.) Ach. "Tree-moss."

Employed by the Indians in some sections for making clothing and bedding, as a yellow dye, a yellow paint and for reducing inflamation of ulcers.—Newberry, 41; Coville, 88; Chesnut, 300.

Fatsia horrida, B. & H. "Devil's Walking Stick."

Used by the Indian medicine-men in their incantations.—Dodge, 407. An aromatic root used by the Crows and Cheyennes mixed with tobacco to smoke for the headache and called "Noachist" or "stinking medicine," appears to be this also.

Fragaria species. "Wild Strawberries."

Eaten fresh by the Indians or dried and stored for winter use. —DeSmet, 117; Catlin, 122; Dodge, 414.

Fraxinus viridis, Michx. "Green Ash."

The wood was quite generally used for bows by the Sioux and probably other tribes.

Fritillaria pudica, Spreng. "Yellow Bell."

According to Lewis & Clark the bulb was eaten by the Indians. Meehan, 44.

Geranium incisum, Nutt. "Wild Red Geranium.

The root is an astringent and has been used as a remedy for diarrhoea.

Glyceria fluitans, R. Br. and **G. aquatica,** Smith. "Sweetgrass."

Used by the Crows and other tribes to burn for incense during certain ceremonies and the seeds were used for food.

Glcyrrhiza lepidota, Pursh. "Wild Liquorice Root."

"Eaten by the Indians of Alaska and the Northwestern states." —Dodge, 407.

Grindelia squarrosa, Dunal. "Rosin-weed"; "Wild Arnica".

"Used by the Indians as an antisyphilitic in decoction". Chickering. Made into tea and taken for kidney trouble by the Sioux; called by them "Aslimtka" or "Slimpi".

Helianthus annuus, L. "Wild Sunflower."

The seeds of this plant appear to have been an important article of diet among Indians and the extensive distribution of this weed over the state is probably largely due to their agency. Havard (p. 1686)

says "Cultivated by the Rees, Gros Ventres and Mandans at Berthold Agency. According to Dr. Mathews, U. S. A. the seeds are dried, slightly scorched in pots or pans on the fire and then powdered. The meal is boiled or made into cakes with grease. The sunflower cakes are often taken on war parties and are said, when eaten even sparingly, to sustain the consumer against fatigue more than any other food." The cultivation of the sunflower is also mentioned in Henry's Journal (Coues, 1:338). The seeds were also eaten raw and an oil was extracted from them, which was employed for the hair or "to lubricate or paint the face or body."—Newberry, 34; Dodge, 419; Lewis & Clark, Coues ed. 2:418.

Helianthus Maximiliani, Schrad. "Wild Artichoke."

Frequent along streams in the eastern part of the state. The tubers are dug and eaten by the Sioux and other tribes.

Heracleum lanatum, Michx. "Cow Parsnip".

A large-leaved, fleshy plant common in low ground in the mountains. The young shoots of the plant were eaten raw by the Indians, much as we do celery. Chesnut (373) reports the same of the Indians in California and says a strong decoction of the roots was used as a cure for the rheumatism.

Ipomoea leptophylla, Torr. "Big Root."

"The Cheyennes, Arapahoes and Kiowas roast it for food when pressed by hunger, but it is by no means palatable or nutritious. Its enormous size and depth in the ground make its extraction by the ordinary Indian implements a work of much difficulty."—Dodge, 407. It is found only in the southestern part of the state.

Iris Missouriensis, Nutt. "Wild Flag"; "Blue Flag."

A decoction of the rootstocks was used by the medicine men to induce vomiting.—Coville, 93.

Juncus Balticus, Willd. "Wire-grass".

Used for weaving mats and light baskets. Coville 92.

Juniperus Sabina procumbens, Pursh. "Trailing Juniper."

The Indians and trappers used the seeds steeped in hot water for kidney trouble and the young twigs and leaves are used for incense by the Crows in their incantations.

Juniperus scopulorum, Sargent. "Red Cedar."

The aromatic twigs are burned by various tribes for incense. The most generally used wood in the state for fence-posts on account of its durability.

Leptotaenia multifida, Nutt. "Wild Parsnip."

"The young sprouts have a pleasant taste and are collected by the Indians as soon as they appear."—Hooker, 237. This plant is quite generally thought to be poisonous to stock in early spring and its use as an article of diet is not recommended without further experimentation.

Leucocrinum montanum, Nutt. "Wild Tuberose"; "Spring Lily".

The roots are eaten by the Crow Indians and are called "Ecopa."

Lewisia rediviva, Pursh. "Bitter-root"; "Racine amare".

This was once an important article of diet among the Indians and is yet used to a considerable extent. "The root is dug during flower-time, when the cuticle is easily removed; by that it acquires a white color, is brittle, and by transportation is broken into small pieces. Before boiling it is steeped in water, which makes it swell and after boiling it becomes five or six times larger in size, resembling a jelly-like substance."—Geyer, 308. "It is very nutritious, but has an exceedingly bitter taste, hence its name. I never could eat it, unless very hungry, but many of the mountaineers are very fond of it."—Stuart 57. See also De Smet, 116; Dodge 407. It was called by the Flatheads "Spatlum" and by the Snakes "Konah".

Linum Lewisii, Pursh. "Blue Flax"; "Wild Flax".

The fibers made from the bark of this native flax were quite generally employed by the Indians for cordage and in the warp of mats, the mesh of snow-shoes, in fish-nets, baskets, etc.—Coville, 92, 94, 99.

Lithospermum angustifolium, Michx. "Indian Paint."

The root is said to produce a violet-colored dye, which was employed by the Indians.

Lobelia inflata, L. "Indian Tobacco".

Said by Hayden (2:739) to be "cultivated by the Crow Indians

in the Yellowstone valley and used in their religious ceremonies," but the species is no longer found in the state, though common farther east.

Lomatium ambiguum, C. &. R., **L. montanum,** C. & R., **L. Cous, C.** & R., **L. platycarpum,** C. & R. and **L. triternatum, C. & R.**
"Bread-root"; "Racine blanche"; "Cous"; "Cous Root;" "Biscuit-root".

"The root is dug in April or May, when in bloom. When fresh it is like the parsnip in taste, and as it dies, becomes brittle and very white, with an agreeable taste of mild celery. It is easily reduced to flour. ' Both the roots and the flour will keep several months." —Dodge, 407, 408. See also DeSmet, 116; Nuttall, 27, 28; Meehan, 29 and Hooker, 235.

Lomatium triternatum, C. & R. (and **L. simplex,** C. & R.?).

"The fusiform root of this species is one of the grateful vegetables of the Indians; they used it baked or roasted."—Pursh, 197. Also eaten raw. The first species occurs only in the western part of the state, the other is common throughout the mountains.

Lonicera involucrata, Banks. "Bearberry"; "Twinberry".

The fruit has a pleasant acid taste and is collected, dried, and stored by the Indians for winter use.

Madia glomerata, Hook. "Tarweed".

The dried herbage is burned as incense by the Crows in some of their ceremonies. Seeds said to be used for food.

Mamillaria Missouriensis, Sweet. "Cushion Cactus".

The fruit is red when ripe and eaten by the Crows, who call it "Michkideamachwa".

Matricaria discoidea, DC. "Green or Rayless Dogfennel."

A decoction of the herbs and flowers used to check diarrhoea. —Chesnut, 395.

Mentha Canadensis, L. "Wild Peppermint."

Leaves made into tea for various complaints.

Mentzelia albicaulis, Dougl. "Sand Lily".

Seeds used for food.—Coville, 11.

Mentzelia lævicaulis, T. & G. "Yellow Sand Lily".

A decoction of the leaves is taken for stomach trouble and applied as a lotion in certain skin diseases.—Chesnut, 370.

Microseris nutans, Gray. "Wild Dandelion."

"Root nearly as large as the little finger, succulent and almost transparent, full of bitterish, milky juice, eaten raw by the Indians". Hooker, 254.

Monarda scabra, Beck. "Horsemint".

A tea made from the leaves is used by the Sioux women after confinement. Called by the Sioux "Okarini pisten" or "Takęn skina zuhapi". The Flatheads apparently use it for a similar purpose.

Moneses uniflora, Gray.

Fruit used for food by the Indians.—Dodge, 414.

Montia asarifolia, Howell; **M. perfoliata,** Howell and **M. parviflora,** Howell. "Squaw Lettuce."

Eaten raw by the Indians as a relish.

Morchella species. "Morelle."

The Crows sometimes use this slimy fungus as a substitute for soap.

Museneon Hookeri, Nutt. "Wild Parsley".

The fleshy root of this species is eaten by the Crows and called by them "marshaspita."

Negundo aceroides, Moench. "Box Elder".

The sap of this tree is boiled down in the spring and made into sugar by the Sioux. Chickering reports a similar use (806).

Nicotiana quadrivalvis, Pursh. "Wild Tobacco".

This species was once cultivated extensively by the Indians throughout the state for smoking, being mixed with one to four times its bulk of "Larb" (Arctostaphylos) or of "Kinnikinnink" (Cornus stolonifera, Mx.) and "The tobacco prepared from it was excellent." The most delicate tobacco was prepared from the flowers. It was never chewed. Yet, at the present time this species is not known anywhere in the state, though a closely related species, N. **attenuata**, Torr., occurs in a number of isolated localities, as if introduced. See Pursh, 141; Douglas, 102; Dodge, 407, and Stewart, 92.

Nuphar advena, Ait. "Yellow Water-Lily".

The thick, fleshy rhizomes of this and the related N. polysepalum, Engelm. were an important article of diet among the several tribes and were said to be sweet and glutinous boiled with fowl or other meat; the seeds were collected, parched and eaten like popcorn or ground into meal for thickening soups; the mucilaginous seed-pods "are well-flavored and nutritious", while the dry, porous rhizomes were ground fine and applied to wounds as a styptic (Sioux). See Newberry, 37; Coville, 96 and Dodge 407.

Opuntia polyacantha, Haw. "Prickly Pear"; "Cactus."

The young joints of the prickly-pear were a regular article of diet with the Indians of the plains and Geyer(26) says they afforded "quite a reasonable refreshment, in taste resembling raw cucumbers". Old settlers report that the process of preparation is to boil the joints, when the skin with its prickles is easily removed. The soft, pulpy interior is then fried and makes and excellent dish. The fruit is red when ripe and is eaten raw by the various tribes; called "Michkidea" by the Crows, "Pomme de raquette" by the French voyageurs and "Tunas" by the Spanish-Americans. The fruit is also made into "preserves" and is doubtless utilized in other ways. The settlers and wood-choppers along the Missouri are said to use the plant for clearing muddy water. The thick, fleshy leaf-like stems are simply split and placed into a receptacle of water, which is at once cleared by the extruded mucilage—a practice doubtless learned from the Indians. In times of scarcity the spines are singed off and the plants are fed to stock.

Oxyria digyna, Campd. "Mountain Sorrel."

The acid-tasting leaves were sometimes used as a salad by the Indians—Dodge, 422. Found only in the mountains above 6000 feet.

Petalostemon violaceus, Michx. "Red Tassel-flower."

The bruised leaves steeped in water are applied to fresh wounds. —Lewis & Clark label in Meehan, 23.

Philadelphus Lewisii, Pursh. "Wild Syringa."

The stems of this shrub were used for arrow-making.—Coville, 97.

Phragmites communis, Trin. "Reed Grass"; "Cane Grass".

It grows to immense size (15 to 18 feet) on the tributaries of the

Missouri and the hard, indurated, hollow culms were used for pipe-stems, arrow-shafts and in basket-making, while the seeds were an article of food. See Coville, 91.

Pinus albicaulis, Engelm. "Nut Pine"; "Alpine Pine".

The Indians were accustomed to peel off the outer bark of this species and then scrape off the inner (called "Sliva") for food. The nuts of this and P. flexilis, James were also an important article of food and were called "Tibap" by the Snakes.

Pinus Murrayana, Murr. "Lodge-pole Pine".

The inner, cambium layer of the bark of this specis was also eaten by the Indians in times of scarcity and baskets were made from sections of the younger bark, while the almost exclusive use of the smaller trees, stripped of their bark, for lodge-poles by the various tribes has given it its name and the Indians of the plains were often compelled to travel hundreds of miles to some fixed locality in the mountains, where at a stated period during the summer they met to hunt and lay in a supply of this necessary article. The poles are slender, straight and light and this species is practically the only tree of this region suitable for forming the frame-work of their teepees and capable of easy transportation. Used extensively for lumber.

Pinus ponderosa, Dougl. "Yellow or Missoula Pine."

The trunks were hollowed by fire into "dug-outs", the twigs used for twirling-sticks in fire-production and the inner bark was employed for food in the spring.—Coville, 89. The most important lumber tree in the state.

Polygala alba, Nutt.

A decoction of the roots is used by the Sioux for ear-ache. An article of barter among the tribes.

Polygonum Douglasii, Greene.

The seeds were parched and made into meal by some of the tribes. Coville, 95.

Polygonum emersum, Britton.

The young shoots were eaten in the spring by the Sioux as a relish.

Populus angustifolia, James; **P. balsamifera,** L.; **P. deltoides,** Marsh and **P. tremuloides,** Michx.

The various species of "cottonwood" and "quaking asp" were utilized by the Indians largely for fire and shelter during the winter, the young twigs were fed to their horses when other food was not obtainable, the inner bark was considered a valuable mucilaginous and anti-scorbutic food as was sometimes used for "kinnikinnink". while the bark of P. tremuloides was sometimes employed as cordage. P. deltoides is used to some extent for lumber, but warps badly unless carefully seasoned.—Havard, 1682; Coues' Lewis & Clark, 1:220; Coville, 94.

Potentilla Anserina, L.

"The roots are eaten by the natives and taste like sweet potatoes'.. —Lewis label, Meehan, 25.

Prunus Americana, Marsh. "Wild Plum."

A small tree or shrub not infrequent in the coulee thickets in the plains region. The ripe plums of this species were used by the Crow Indians both fresh and dried for winter use and now appear upon our markets in season as "wild plums." As a hardy plum adapted to our climate it offers great horticultural possibilities, though it rarely here ever becomes more than a shub 12 or 15 ft high.

Prunus demissa, Walp. "Choke Cherry."

Called "Malupwa" by the Crows and "Schlascha" by the Flathead Indians. The dried roots are chewed and placed in wounds to stop bleeding by the Sioux; the bark is made into tea as a remedy for dysentery; the wood is fashioned into "medicine-spoons," some three feet long for use in the ceremonial dog feasts of the Sioux; the straight shoots were made into arrow-shafts and the fruit is an important article of diet in the economy of the Indian household. The fruit is collected, crushed in a mortar, cut into strips three or four inches long and one wide, dried and stored for winter use. It was also eaten fresh and was an important ingredient in the preparation of "pemmican", so highly valued by the trapper and hunter of the early day. Nor has its value as a food diminished with the coming of civilization. The ripe fruit of this species is collected each fall in many parts of the state and made into wine and marmalade. The latter is usually prepared by cooking the ripe fruit,

straining out the seeds and skins through a colander, and then mixing with an equal quantity of plums or crab-apples to modify the harsh, astringent, bitterish taste. This "choke-cherry butter" thus prepared is highly prized as a food throughout the state and only needs to be better known to become a regular article of commerce.

Pseudotsuga mucronata, Sudw. "Red Fir"; "Douglas Fir".

The leaves are sometimes used as a substitute for coffee and in the sweat-bath as a cure for rheumatism, while the spring buds are made into a decoction as a remedy for certain venereal diseases. —Chesnut, 309. Now used extensively for lumber.

Psoralea argophylla, Pursh.

"A decoction of the plant used by the Indians to wash their wounds."—Lewis label in Meehan, 23.

Psoralea esculenta, Pursh. "Indian Turnip"; "Bread-root".

The "pomme blanche" and "pomme de prairie" of the French voyageurs the "Aha" and "Esharusha" of the Crows and the "Tipsinnah" of the Sioux. 'The famous Bread-root of the American Western Indians on which they partly subsist in winter. They collect them in large quantities and, if for present use, roast them in the ashes, when they give a food similar to yams; if intended for winter use, they are carefully dried and preserved in a dry place in their huts. When wanted for food, they are mashed between two stones, mixed with some water and baked in cakes over the coals. It is a wholesome and nourishing food."—Pursh, 476. These tuber-like, starchy roots are yet dug, peeled, sliced into strips and dried for winter food by the tribes of the plains where the plant is native.

Pteris aquilina, L. "Brake Fern".

The root is used for food by many of the tribes, the bark being removed and the white "heart being roasted, it resembles both in appearance and flavor the dough of wheat. It has a pungency which is disagreeable to the whites, but by the aborigines is much relished and it proves to be nutritious."—Dodge, 408. Found here only west of the Divide.

Purshia tridentata, DC.

The roots are steeped in water, which is used for lung troubles and is reputed of high value by the Indians. The dry ripe fruits

are mashed in cold water and employed as an emetic, while the outer seed-coats are used to make a purple stain for wood.—Coville, 98.

Rhamnus Purshiana, DC. "Cascara Tree."

The leaves, bark and fruit are made into a decoction and used as an emetic by Indians.—Coville, 100. The fruit is reputed poisonous by the Flatheads. The bark is now largely the source of the Cascara Sagrada of medicine. Noted in the state only around the Mission Mountains.

Ribes setosum, Lindl., **R. floridum,** L'Her., **R. lacustre,** Poir., **R. aureum,** Pursh, **R. petiolare** Dougl., **R. viscosisimum,** Pursh and **R. cereum,** Dougl. "Wild Gooseberry"; Wild Currant".

All these species and some others were employed by the Indians as an article of diet and highly esteemed, though the viscidity of the fruit of the last two species and R. lacustre render them objectionable to more fastidious tastes. The fruit of R. setosum and R. floridum is still sought in season in the settled communities, where the garden varieties are not obtainable.

Rosa acicularis, Lindl., R. **Nutkana,** Lindl., **R. Sayi,** Schwein, and **R. Woodsii,** Lindl. Wild Rose."

The fruit of these various species was utilized by the Indians for food and the "hips" of the first two species after frost are quite palatable, but that of the last, though occasionally used by the Sioux in extremity, is not to be recommended. The latter is the wild rose of the plains, the others are found only in the mountains. See De Smet, 116; Havard, 1683.

Rhus trilobata, Nutt. "Sweet Sumac".

The aromatic, acid berries are eaten by the Indians and hunters and the powdered fruit is applied as a lotion or dusted upon the affected surface in cases of small-pox.—Geyer, 37; Chesnut, 365.

Rubus Nutkanus, Moc. "Timble-berry"; "Salmon-berry."

In spring the Indians consume the young sprouts in great quantities. They are very tender with a slightly acid and astringent taste and are highly relished. They are a valuable alterative and antiscorbutic.—Dodge, 415. These young sprouts were eaten raw or tied into bundles and steamed.—Meehan, 26.

Rubus strigosus, Michx. "Red Raspberry".

The wild raspberry is frequent in the mountains and its fruit is highly esteemed by both whites and aborigines. The black species (R. leucoderme, Dougl.) is much less frequent, being found only west of the Divide.

Rumex crispus, L., **R. salicifolius,** Weinm. and **R. occidentalis,** Wats. "Dock;" "Sour Dock".

The leaves of these species are used for "greens" in the spring by the Indians and whites; and the seeds were also used for food by the former.—Coville, 95; Chesnut, 346.

Rumex Geyeri, Trel. "Mountain Dock."

The herbage was eaten raw by the Indians.—Coville, 90. Found only in the mountain meadows.

Sagittaria arifolia, Nutt. "Wappatoo"; "Swamp Potato".

Common in slow-flowing streams throughout the state. The tubers are "generally as large as hen's eggs and are greatly relished when raw, but have a bitter, milky juice, not agreeable to civilized man. This is destroyed in boiling, however, and the roots are rendered sweet and palatable."—Dodge, 408. See also DeSmet, 116. The Indians wade into the water and loosen these tubers with their feet, when they float to the top and are collected.

Salix fluviatilis, Nutt. and **S. exigua,** Nutt. "Narrow-leaved Willow."

Common along the Missouri and its tributaries up to 5000 feet. This was the species commonly used by the Indians to make the framework of their "sweat tepees", which was then covered with skins or blankets and filled with steam produced by pouring water over hot stones. After profuse perspiration in this steam chamber, the subject was taken out and doused with cold water, after the manner of the Russian bath. This remedy for colds, rheumatism and various other diseases is still employed extensively by the Indians and their camping places are always marked by the abandoned framework of these sweat-tepees, which were formed by sharpening both ends of willow poles 12 or 15 feet long, bending them over and sticking both ends into the ground from various directions. The Mandans wove mats for the floor out of willows, the Flatheads made baskets cemented with gum in which they cooked fish by heating the water with hot stones and they were extensively used for

cordage by all the tribes. The bark is also said to be used as a remedy for certain fevers. See De Smet, 119; Coues' Lewis & Clark, 2:410 and Henry's Journal, 1:339.

Salix Mackenziana, Barratt. "Diamond Willow".

The younger stems form diamond-shaped excrescences about the "knots" and are quite ornamental when the bark is removed. Employed extensively for making "walking-sticks."

Sambucus glauca, Nutt. "Elder-berry".

The fruit of this species is sweet and edible and was eaten raw or cooked. It is now frequently employed for pies, jelly and wine, but the fruit lacks acidity. A decoction of the dried flowers is applied externally as a remedy for sprains and bruises and in fevers, as an antiseptic wash for open sores and for the itch and is used internally for lung and stomach troubles, while the inner bark is a strong emetic. The wood is used as a twirling-stick in fire-making. See Chesnut, 389; Geyer, 1846; Newberry, 45. Found here only west of the Divide.

Sarcobatus vermiculatus, Torr. "Greasewood".

The young twigs of the greasewood are said to make excellent "greens" and the early settlers probably learned their use from the Indians.

Scirpus campestris, Britton.

Found abundantly about alkali lakes in the plains. The large pear-shaped tubers were extensively employed for food by the Indians and were dug in the autum.—Geyer, 290.

Scirpus lacustris occidentalis, Wats. "Bulrush;" "Tule."

A tall sedge growing in the water and in wet places, not infrequent. The roots were eaten by the Indians both raw and made into bread. The "flour is white, sweet and very nutritious." A syrup was made from them by boiling with water and, chewed dry, served as a preventative to thirst. The stems were used for making mats and the seeds were employed for food. The young shoots are pulled up and eaten in the spring by the Sioux.—Coville 92; Dodge, 408.

Shepherdia argentea, Nutt. "Buffalo-berry;" "Bull-berry."

Common along the Missouri and its tributaries up to 4000 feet.

The red, acid fruit is highly esteemed by all the tribes of the plains and was eaten both fresh and dried for winter use. Called "Marishisha" by the Crows, "Ingahawmp" by the Snakes and "Graisse de boeuf" by French voyageurs. Nor has its value diminished with the coming of civilization for they are still found in our autumn markets and are highly esteemed for jelly, the demand exceeding the supply. If the larger, sweeter, yellow colored variety could be made thornless, it would become one of the most valued fruits of the orchard for the whole semi-arid region of the plains.

Shepherdia Canadensis, Nutt.

A shrub of the mountain region and far northward; fruit red. sometimes yellow. The bark is used by the Sioux as a remedy for diarrhoea and the root said to be a cathartic, while the fruit is very acrid and reputed poisonous, but yet is employed by the Flathead Indians and the whites in that section to concoct a peculiar drink, which is greatly prized and highly recommended. A tablespoonful of the ripe berries is tied up in a cloth bag and rubbed up with a cup of water in a clean pail, so that it forms a large mass of foam, somewhat resembling ice-cream, to which, when nearly done, is added sugar and lemon or vanilla to suit the taste. The resultant product is said to be slightly bitter, but a liking for the beverage is soon acquired.

Sisymbrium incisum, Engelm. "Tansy Mustard."

The seeds are parched and ground for food by the Indians.—Coville, 97.

Sium cicutæfolium, Gmel.

According to Coville (102) the herbage of this plant has an aromatic flavor and is eaten as a relish by the Indians.

Symphoricarpus occidentalis, Hook. "Juneberry;" "Buckbush."

The fruit of this and related species was eaten by the Sioux and other tribes, the slender twigs were used for arrow-shafts and the collected shrubs were made into brooms. See Dodge, 415; Chesnut, 391.

Taxus brevifolia, Nutt. "Ground Hemlock."

The wood was used by the Indians for making bows.—Chesnut, 305; Coville, 89.

Thuja plicata, Don. "White Cedar"; "Cedar".

The bark was used by the Indians to make canoes and for the frame-work of "basket-willows"; the inner bass was made into sacks, into cords for fishnets, and woven into cloth; the wood was employed for floats for their nets; the roots were used for making baskets and the cambium in the spring was utilized for food, eaten fresh or pressed into cakes and dried for storage.—Dodge, 411, 412; Geyer, 290; Douglas, 90, 117; Hooker, 98.

The wood is now extensively used for shingles and lumber, for fence posts and for paving.

Triglochin maritimum, L.

The seeds were used for food by the Indians.—Coville, 90.

Tsuga heterophylla, Sargent. "Hemlock".

The bark was used by the Indians for tanning and the cambium was made into a coarse bread.—Sargent, Sylva, 11:93, 12:75.

Typha latifolia, L. "Cat-tail"; "Cat-tail Flag".

The young roots and shoots are eaten raw by the Sioux and other tribes; the leaves were used for matting and the "down" of the fruit-spikes for bedding and for application to burns and scalds. —Bradbury, 62; Geyer, 290; Chesnut, 310; Coville, 90. The Sioux were accustomed to treat small-pox by frying out the fat of the coyote and making a plaster by mixing it with the "down" of the fruit, which they applied to the pustules of the patient.

Ulmus Americanus, L. "Elm"; "White Elm".

The inner bark was used as an emollient for tumors. Coues' Lewis & Clark, 1:50.

Urtica gracilis, Ait. "Nettle"; "Stinging Nettle".

The root, called by the Sioux "Shanpi" or "Wicaro nakum," was used as a remedy for retention of urine. The bark appears to have been used for cordage and the young shoots were employed as a pot-herb.

Vaccinium membranaceum, Dougl. "Huckleberry."

The ripe fruit was gathered extensively in season and eaten fresh or dried for winter. It is found abundant in the mountains and is still highly valued for making pies, jelly etc., for which it

can occasionally be purchased in the markets. The fruit of other species of Vaccinium was also an article of diet of the Indians, but of little importance compared with the last.

Valeriana edulis, Nutt. "Tobacco-root".

Called "Quee" or Queeah" by the Snakes, and "Racine de tabac," by the Canadian voyageurs and trappers "This is a root about the size and length of the finger; it is of a deep yellow color and grows on the bottoms along many of the streams. It is poisonous when raw, but the Indians cook large quantities of it in a kind of kiln, the process occupying several days. When done it is perfectly black and very sticky. It has a very strong smell, which is extremely offensive to those who are not used to it."—Stuart, 93. "When, like Gamass, it is an agreeable food to the Indians, but very disgusting to white people, having the nauseous odor of chewed tobacco."—Hooker, 239.

The plant is frequent throughout the mountainous parts of the state and in the fresh state the root tastes much like the radish, but is reputed poisonous. See also Geyer, 297; Dodge, 409; Gray, II :43.

Vicia Americana, Muhl. "Wild Pea." . .

"When young it is often cooked and eaten for greens by various tribes."—Chesnut, 362.

Vitis vulpina, L. "Wild Grape".

This is native in the state up the Missouri as far as Poplar (Ft. Peck), up the Yellowstone to Pompey's Pillar and the Little Big Horn to beyond the Crow Agency. The fruit is collected and eaten both fresh and dried by the Sioux and Crows.

Wyethia amplexicaulis, Nutt.

"The root after heat and fermentation by which process it becomes somewhat saccharine, is then eaten by the natives."—Nuttall, 38.

Wyethia helianthoides, Nutt. "White Sunflower".

This and Balsamorrhiza sagittata, Nutt. were treated like the last and employed for food.—Nuttall, 40.

Xerophyllum Douglasii, Wats. and **X. tenax,** Nutt. "Bear-grass."

"This plant is very useful to the natives; out of its very tenacious leaves they weave their water-tight baskets, which they use for cooking their victuals in."—Pursh, 243. See Lewis label in Meehan, 44. One or the other of these species is common along the main chain of the Rockies in the open forests at medium elevations and frequent west of the Divide and is destined to play an important part in our economic life, when its value has once been tested.

Yucca angustifolia, Nutt. "Soap Weed;" "Grass Cactus."

The roots of this species appear to have been extensively employed as a substitute for soap by the various tribes occupying the eastern plains, where it is native. It is said to be particularly valuable as a hair-wash, yielding a lustre not otherwise obtainable. See Dodge, 43.

Zygadenus venenosus, Wats. "Death Camas".

"Rather generally used as an external cure for boils and rheumatism and to alleviate pain caused by strains and bruises. The bulbs are generally cooked, mashed and bound as a poultice to the parts affected for about 12 hours". For the cure of rheumatism the fresh bulb is mashed and rubbed on the affected joints twice a day for a period of about a month.—Chesnut, 322; Coville, 93.

In addition to the plants now native within the state the various tribes cultivated certain other plants, which now have long been domesticated, such as the bean (De Smet; Lewis & Clark"), the water-melon, (De Smet), maize, the potato, (De Smet, 116) and the tobacco (Douglas, 102).

Pemmican was made by the Sioux and other tribes by mixing certain berries, such as the buffalo-berry, the choke-cherry and the sarvice berry with the fat of the buffalo, pounding up the whole and packing away in skins. Sometimes jerked buffalo was put into an oven to render brittle, beaten up on a skin with these berries, some marrow-fat being added to give consistency, and finally packed in skin bags. This was a regular article of commerce and highly prized by the old trappers and hunters for its portability as a condensed food and for its keeping qualities. Later the flesh and tallow of the ox was substituted for that of the buffalo and is still used to some extent.

Besides the native poisonous herbs, like the water-hemlock and the death camas, the Flathead medicine men were said to distil a particularly virulent poison, the effect of which was slow but sure. They were accustomed to hang up a toad by its hind legs until dead then allow it to putrify, collecting the drops of liquid exuding and preserving them to administer to doubting Thomases or undesirable friends. This bacterial ptomaine should therefore be called to the attention of physicians having to do with the various tribes.

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NATIVE PLANTS ARRANGED BY THEIR USES.

I. DOMESTIC ARTS.

1. IMPLEMENTS.

For War, Hunting and Fishing:

Arrow-shafts: Amelanchier alnifolia, Philadelphus Lewisii, Phragmites communis Prunus demissa, Symphoricarpus occedentalis

Bows: Fraxinus viridis, Taxus brevifolia.

Canoes: Betula papyrifera, Pinus ponderosa, Thuja plicata.

Fishnets: Acer glabrum, Cornus stolonifera, Linum Lewisii, Thuja plicata.

Fish-spears: Cercocarpus ledifolius.

For Household Employments:

Brooms: Symphoricarpus occidentalis.

Digging-sticks: Cercocarpus ledifolius, Crataegus Douglasii.

Pipe-stems: Phragmites communis.

Walking-sticks: Salix Mackenziana.

Twirling-sticks: Artemisia tridentata, Pinus ponderosa, Thuja plicata.

2. CEREMONIAL AGENTS.

Incantations: Fatsia horrida, Lobelia inflata.

Incense: Abies lasiocarpa, Glyceria aquatica, G. fluitans Juniperus scopulorum, J. Sabina procumbens, Madia glomerata.

Medicine Spoons: Prunus demissa.

3. GENERAL UTILITIES.

Lodge-poles: Pinus Murrayana.

Sweat tepees: Salix fluviatilis, S. exigua.

Lumber: Pinus ponderosa, P. Murrayana, P. monticola, Larix occidentalis, Picea Engelmanni, P. alba, Populus deltoides, Pseudotsuga mucronata, Thuja plicata.

Fencing: Juniperus scopulorum, Thuja plicata.

Ornamental vines: Ampelopsis quinquefolia, Clematis ligusticifolia, Lonicera ciliosa, Humulus Lupulus, Echinocystis lobata.

Fibers and cordage: Apocynum androsæmifolium, Linum

Lewisii, Populus tremuloides, Salix fluviatilis, S. exigua, Thuja plicata, Urtica gracilis, Xerophyllum Douglasii, X. tenax.

Baskets: Betula papyrifera, Juncus Balticus, Phragmites communis, Thuja plicata, Salix fluviatilis, S. exigua, Xerophyllum Douglasii, X. tenax.

Mats: Carex, Juncus Balticus, Linum Lewisii, Salix, Scirpus lacustris, Typha latifolia.

Clothing and bedding: Evernia vulpina, Thuja plicata, Typha latifolia.

Soap: Morchella, Yucca augustifolia.

Hair-washes. Yucca angustifolia.

Oils: Helianthus annuus.

Paints, dyes and stains: Evernia vulpina, Alnus, tenufolia, Bazzania trilobata, Lithospermum angustifolium, Purshia tridentata.

Tanning: Alnus tenuifolia, Tsuga heterophylla.

Clearing water: Opuntia polyacantha.

Weather Prediction: Bouteloua oligostachya.

Branding: Asclepias speciosa.

II. FOODS.

1. FOODS PROPER.

Roots, Bulbs and Tubers: Allium, Balsamorrhiza incana, B. sagittata, Calochortus, Camassia esculenta, Carum Gairdneri, Claytonia multicaulis, Cnicus eriocephalus, Erythronium grandiflorum, Fritillaria pudica, Glycyrrhiza lepidota, Helianthus Maximiliani, Ipomœa leptophylla, Leucocrinum montanum, Lewisia rediviva, Lomatium Cous & spp., Microseris nutans, Musenion Hookeri, Nuphar advena, N. polysepalum, Potentilla anserina, Psoralea esculenta, Pteris aquilina, Sagittaria arifolia, Scirpus campestris, S. lacustris, Typha latifolia, Valeriana edulis, Wyethia helianthoides, W. amplexicaulis.

Herbage: Salads and Relishes: Balsamorrhiza sagittata, Carex, Cnicus eriocephalus, Heracleum lanatum, Leptotænia multifida, Montia asarifolia, M. perfoliata, M. parviflora, Oxyria digyna, Polygonum emersum, Rubus Nutkanus, Rumex Geyeri, Scirpus lacustris, Sium cicutæfolium, Typha latifolia.

Pot-herbs and Greens: Alectoria Fremontii, Amaranthus blitoides, Chenopodium album, Opuntia polyacantha, Rumex salicifolius, R. occidentalis, Sarcobatus vermiculatus, Urtica gracilis, Vicia Americana.

Bark: Pinus albicaulis, P. Murrayana, P. ponderosa, Thuja plicata, Tsuga heterophylla, and other Conifers.

Fruits and Seeds: Amaranthus blitoides, Ampelopsis quinquefolia, Arctostaphylos Uva-ursi, Asclepias speciosa, Astragalus caryocarpus, Balsamorrhiza sagittata, Beckmannia erucæformis. Berberis repens, Chenopodium album, Cratægus Columbiana, C. Douglasii, Elæagnus argentea, Eriocoma cuspidata, Fragaria bracteata, F. glauca, Helianthus annuus, Iva xanthiifolia, Lonicera involucrata, Madia glomerata, Mamillaria Missouriensis, Mentzelia albicaulis, Moneses uniflora, Nuphar advena, N. polysepalum, Opuntia polyacantha, Phragmites communis, Pinus albicaulis, P. flexilis, Polygonum Douglasii, Prunus Americana, P. demissa, Ribes floridum, R. setosum, R. aureum, Rosa acicularis, R. Nutkana, Rhus trilobata, Rubus strigosus, Rumex salicifolius, R. occidentalis, Sambucus glauca, Scirpus lacustris, Shepherdia argentea, Sisymbrium incisum, Smphoricarpus occidentalis, Triglochin maritimum, Vaccinium membranaceum, Vitis vulpina.

Meal and Flour: Balsamorrhiza sagittata, Chenopodium album, Helianthus annuus, Iva xanthiifolia, Lomatium Cous, L. montanum, L. ambiguum, Nuphar polysepalum, Psoralea esculenta, Pteris aquilina, Tsuga heterophylla, Scirpus lacustris.

Sugar and Syrup: Negundo aceroides, Scirpus lacustris.

Pemmican: Prunus demissa; p. 27.

Jellies, Jams, Preserves and Marmalade: Amelanchier alnifolia, Opuntia polyacantha, Prunus Americana, P. demissa, Ribes species, Rubus strigosus, Shepherdia argentea, Vaccinium membranaceum, Berberis repens, Sambucus glauca.

2. BEVERAGES.

Amelanchier alnifolia, Berberis repens, Prunus, demissa, Pseudotsuga mucronata, Shepherdia Canadensis.

3. SMOKING.

Arctostaphylos Uva-ursi, Cornus stolonifera, Nicotiana quadrivalvis, Populus balsamifera, P. deltoides.

4. FORAGE.

Agropyron occidentale, Boutcloua oligostachya, Opuntia polyacantha, Populus balsamifera, P. angustifolia, P. tremuloides and many other plants.

III. MEDICINES.

1. PROPERTIES AND USES.

Abortifacients: Acorus Calamus, Claviceps (Elymus condensatus), Monarda scabra.

Antidote for snake-bite: Echinacea angustifolia, Steironema ciliatum (?).

Antiscorbutics: Populus, Rubus Nutkanus.

Antiseptics: Abies lasiocarpa, Sambucus glauca.

Antisyphilitics: Grindelia squarrosa, Pseudotsuga mucronata.

Astringents: Geranium incisum, Prunus demissa, Salix.

Alteratives: Rubus Nutkanus.

Carminatives: Mentha Canadensis, Monarda scabra.

Cathartics: Achillea lanulosa, Apocynum androsæmifolium, Aralia nudicaulis, Rhamnus Purshiana, Shepherdia Canadensis.

Diuretics: Urtica gracilis.

Emetics: Iris Missouriensis, Purshia tridentata, Sambucus glauca.

Emollients: Ulmus Americana, Erythronium grandiflorum Zygadenus venenosus.

Febrifuges: Apocynum androsæmifolium, Berberis repens, Chimaphila umbellata, Salix Sambucus glauca.

Hair restorers: Artemisia cana.

Lotions: Achillea millefolium, Cornus stolonifera, Mentzelia lævicaulis, Petalostemon violaceus, Rhus trilobata, Artemisia tridentata, Psoralea argophylla.

Poisons: Aphyllon fasciculatum, Apocynum androsæmifolium, Cicuta occidentalis, Leptotænia multifida, Rhamnus Purshiana.

Shepherdia Canadensis, Valeriana edulis, Zygadenus venenosus; p. 28.

Poultices: Abies lasiocarpa, Artemisia tridentata, Erythronium grandiflorum, Ulmus Americana, Evernia vulpina, Zygadenus venenosus.

Salivants: Echinacea angustifolia.

Stimulants: Clematis Douglasii, Echinacea augustifolia.

Styptics: Calvatia gigantica, Nuphar polysepalum, Prunus demissa.

Thirst-prevention: Artemisia cana, Scirpus lacustris.

Tonics Apocynum androsæmifolium, Aralia nudicaulis, Artemisa cana, Berberis repens, Chimaphila umbellata, Salix.

2. DISEASES.

Boils and Tumors: Ulmus Americanus, Erythronium grandiflorum, Zygadenus venenosus.

Bruises: see "Sprains" below.

Burns and Scalds: Typha latifolia.

Cancer: Aphyllon fasciculatum.

Corns: Abies lasiocarpa.

Colds: Clematis ligusticifolia; see Salix.

Consumption: Achillea millefolium, Artemisia frigida; see "Pulmonary."

Diarrhea: Artemisia tridentata, Geranium incisum, Matricaria discoidea, Prunus demissa, Shepherdia Canadensis.

Ear-ache: Polygala alba.

Eye diseases: Achillea millefolium, Artemisia tridenta.

Fevers: Apocynum androsæmilfolium, Berberis repens, Chimaphila umbellata, Salix, Sambucus glauca.

Headache: Achillea millefolium, Clematis Douglasii, Fatsia horrida.

Kidney diseases: Berberis repens, Grindelia squarrosa, Juni perus Sabina procumbens, Urtica gracilis.

Mountain Fever: Berberis repens.

Pulmonary diseases: Abies lasiocarpa, Achillea millefolium, Artemisia frigida, Clematis lingusticfolia, Purshia tridentata, Sambucus glauca; see also under Salix.

Rheumatism: Heracleum lanatum, Pseudotsuga mucronata. Zygadenus venenosus; see also under Salix. The Blackfeet are said to employ a small trailing plant made into poultices for external application, which turns the skin black temporarily, but is highly efficacious. I have been unable to secure specimens of this plant for identification. It is found only in the higher mountains.

Skin diseases: Mentzelia lævicaulis, Sambucus glauca.

Smallpox: Rhus trilobata, Typha latifolia.

Snake-bite: Echinacea augustifolia, Steironema ciliatum (?).

Sprains and Bruises: Achillea millefolium, Artemisia tridentata, Sambucus glauca, Zygadenus venenosus.

Stomach troubles: Achillea millefolium, Berberis repens, Mentzelia lævicaulis, Sambucus glauca.

Throat diseases: Clematis ligusticifolia.

Ulcers: Abies lasiocarpa, Evernia vulpina, Cornus stolonifera.

Urinary complaints: See "Kidney."

Venereal diseases: Grindelia squarrosa, Pseudotsuga mucronata.

Wounds: Psoralea argophylla, Prunus demissa, Petalostemon violaceus.

INDEX OF COMMON NAMES.

Montana Agricultural College Experiment Station

F. B. LINFIELD, Director

BULLETIN NO. 57

FEEDING PIGS

FOR THE YEARS 1903 AND 1904

BY

F. B. LINFIELD
Animal Industry

BOZEMAN, MONTANA
SEPTEMBER
1905

MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION

BOZEMAN, MONTANA

Post Office, Express and Freight Station, Bozeman.

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Bozeman, Montana.

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PIG FEEDING EXPERIMENTS

INTRODUCTION.

There has been but little work done in feeding experiments with hogs at the Montana Experiment Station for the past three years. This has been due to various causes: First, because the facilities for the work were very unsatisfactory, and second because the pressure of other duties has kept the farm help very busy. During the past year conditions have improved. The new piggery provides very fair facilities for the feeding and with the segregation of the farm and live stock work it has been possible to give more consecutive time to our live stock experiments.

An important object in these pig feeding experiments has been to study the effect and value of various supplementary foods when fed with grain, as compared with grain alone as a fattening ration for hogs. A few other factors have, however, been also considered. This is a series of experiments which we plan to continue for some time and hope also to broaden the scope of the work, which will make the result more and more valuable as time passes and experiments increase in number. Previous experiments along this line are reported in bulletins 27 and 37 of this station. In this bulletin four experiments are reported, one conducted during the winter of 1903 and three others during the past season. The plan of managing and feeding hogs was very similar throughout all the tests. The feed was weighed at each time of feeding, the hogs being given their feed twice a day. The grain has been usually fed as a slop being wet with water or with skim milk. The hay was generally kept in a small rack in the pen where the hogs could have access to it at any time. The roots given were in nearly every case the sugar beets. These were generally cut and the hogs were given what they would eat. The prices for the grain and other foods given were as follow by years:

	1902-3	1904-5
Wheat, per 100 pounds	$1.00	$1.25
Barley, per 100 pounds	1.00	1.00
Bran, per 100 pounds	.85	.95

Roots, per 100 pounds	20c, or $4.00 per ton
Clover or alfalfa, per 100 pounds	25c, or $5.00 per ton
Skim milk, per 100 pounds	15c, or $3.00 per ton

The plan of weighing the hogs was to weigh them three days in succession at the beginning of the test and once every two weeks so that the progress of their growth could be noted, and then three times at the close of the experiment so as to get the correct average weight.

THE FIRST EXPERIMENT.

INTRODUCTION.

The first experiment was conducted during the winter of 1903. The purpose of the test was to compare the relative efficiency of grain and hay, and grain and roots, when fed in small pens with an outside run, or when fed in small pens without the outside run. These hogs were fed in the old piggery which was built of logs. It had a cement floor which was cold during the winter and the pens without the outside runs were quite small and dark. The question on this point then was to fatten without exercise or with a limited amount of exercise in the pens with the outside yards. The hogs in this test were partly Berkshire and Poland Chinas and the others Yorkshire and Berkshire cross; quite a thrifty lot of pigs. There were four pigs in each lot. At the beginning of the test the pigs averaged 65 to 69 pounds each. The grain in this test consisted of a mixture of wheat, barley and bran, equal parts of each by weight.

THE GAINS MADE.

It will be noted that the hogs in the small inside pen ate less grain than those in the pen with the outside run. They also gained considerably less per day than those outside. The hogs in the pens with the outside run gained about .6 of a pound per day whereas those in the small pens gained but .36 pounds per day. These gains are very small and very much below the average usually obtained with such pigs. This was probably due to the uncomfortable quarters and to the fact that some of the pigs were rather small when started in the test.

Considering the hogs fed the alfalfa hay as contrasted with the roots, it will be noted that those fed roots and grain in the pen with the outside run gained 26 pounds more than the lot fed on alfalfa hay and grain. In the small pens the result was reversed, the hogs

getting the alfalfa hay gaining 38 pounds more than the lot fed on the roots.

POUNDS OF FOOD FOR ONE POUND OF GAIN.

Considering first the two lots fed where they could exercise as compared to those that could not, we note that it took less feed for each pound of grain where the hogs had a chance to exercise in the yard. The difference on the average, is close to 1½ pounds more grain required by the pigs without exercise.

Considering the comparison between the hay and the root ration we find that the hogs fed the roots, with exercise, required less grain than those fed on the alfalfa hay, for each pound of gain made. The difference in favor of the root ration is .87 pounds of grain. For the lot fed in the small pens without the exercise the hogs fed on alfalfa and grain required the least grain for each pound of increase in live weight which is the converse of those fed outside. The reason for these differences I will not at present attempt to explain as the test should be repeated before any definite conclusions can be drawn.

THE RETURNS FROM THE FEEDING.

As the price of hogs vary at different seasons of the year it was thought best not to use the prices obtained for the hogs in this experiment but to fix on an arbitrary price of from 4 to 6 cents per pound; 4 cents being a little low for hogs in this valley and 6 cents being an average to a high price. The value put upon the grain fed is the market price which of course means that if the grain was sold for this price it should return a profit to the owner. If an additional profit can be obtained by feeding it to the hogs there is that much advantage over selling it off the farm as grain. The returns for the grain per hundred pounds with hogs selling at 4 to 6 cents is figured out by deducting the value of hay and roots and other supplementary food from the value of the gains made and then calculating the amount that should be credited to the grain. This is not strictly correct as if these gains did not return a market price for the grain they are not likely to return the market price for the supplementry food given them, so that this reduced price should be charged against all of the feeds given; but as we have no basis from

TABLE I—PIG FEEDING EXPERIMENTS.

	Rations Fed	No. of Hogs	Days Fed	Pounds of Food Eaten				Weight at beginning	Weight at end	Total gain	Average gain per day per hog
				Grain	Alfalfa Hay	Roots	Milk				
	Winter of 1903—										
Lot 1	Grain and hay, with outside run...............	4	80	1074	137	...	....	264	447	183	0.57
Lot 2	Grain and roots, with outside run..............	4	80	1046	...	560	....	275	484	209	.65
Lot 3	Grain and hay, without outside run......... ...	4	80	883	233	...	....	261	395	134	.42
Lot 4	Grain and roots, without outside run............	4	80	708	...	543	....	262	358	96	.30
	Fall of 1904—				Clover						
Lot 1	Barley and bran. (Fed in pens)...............	5	98	2470	...	...	....	449	908	459	.94
Lot 2	Grain and skim milk. (Fed in pens)..........	5	98	2296	...	...	6493	468	1153	685	1.40
Lot 3	Grain and clover. (Fed in pens).............	5	98	2691	485	...	....	466	1015	549	1.12
	Spring of 1905—				Clover						
Lot 1	Barley and bran. (Fed in pens-...............	4	81	1547	...	...	....	335	632	297	.90
Lot 2	Grain and skim milk. (Fed in pens).........	4	81	1350	...	...	3714	339	779	440	1.34
Lot 3	Grain and clover hay. (Fed in pens)..........	4	81	1409	328	...	....	345	636	291	.89
Lot 4	Grain and sugar beets. (Fed in pens).........	4	81	1348	...	1369	....	346	704	358	1.09
	Supplementary Test, 1905—										
Lot 1	Grain, roots, and skim milk....................	4	17	340	...	255	382	632	758	126	1.85
Lot 3	Grain, roots, and skim milk....................	4	17	340	...	255	382	636	756	120	1.76
	Summer of 1905—										
Lot 1	Grain and water. (All on pasture).........	3	55	932	...	...	....	268	500	232	1.41
Lot 2	Grain and skim milk. (All on pasture)..........	2	55	546	...	...	1638	227	414	187	1.70
Lot 3	One-half grain, and water. (All on pasture) ...	3	55	466	...	...	....	275	431	156	.94

TABLE I—PIG FEEDING EXPERIMENTS. (Continued.)

		Pounds food to 1 lb. gain				Value of grain fed.	Value of gain at		Pounds of grain saved by 100 lbs. of			Return for grain per 100 lbs. when hogs sell for	
		Grain	Alfalfa Hay	Roots	Milk		4c per lb.	6c per lb.	Hay	Roots	Milk	4c per lb.	6c per lb.
	Winter of 1903—												
Lot 1	Grain and hay....................	5.87	.75	....	....	$ 9.66	$ 7.32	$10.98	....	....	....	65.0	98.0
Lot 2	Grain and roots..................	5.00	....	2.68	....	9.41	8.36	12.54	....	....	....	69.2	109.2
Lot 3	Grain and hay....................	6.59	1.74	....	....	7.94	5.36	8.04	....	....	....	54.1	84.5
Lot 4	Grain and roots..................	7.38	....	5.66	....	6.37	3.84	5.76	....	....	....	39.0	66.0
	Fall of 1904—		Clover										
Lot 1	Grain	5.36	....	....	....	23.96	18.36	27.55	....	....	....	74.3	111.5
Lot 2	Grain and skim milk..............	3.35	....	....	9.46	22.27	27.40	39.10	....	....	21.1	77.1	123.7
Lot 3	Grain and clover	4.90	.88	....	....	26.10	21.96	32.94	52.3	....	....	77.1	114.2
	Spring of 1905—												
Lot 1	Grain	5.21	....	....	....	15.00	11.88	17.82	....	....	....	77.0	115.2
Lot 2	Grain and skim milk	3.07	....	....	8.44	13.09	17.60	26.40	....	....	25.2	89.1	151.3
Lot 3	Grain and clover	4.84	1.13	....	....	13.67	11.64	17.46	32.7	....	....	76.7	118.1
Lot 4	Grain and roots..................	3.76	....	3.80	....	13.07	14.32	21.48	....	38.2	....	85.9	139.0
	Supplementary Test—												
Lot 1	Grain, roots and skim milk.......	2.70	....	2.02	3.03	3.30	5.04	7.56	....	....	....	116.4	190.5
Lot 3	Grain, roots and skim milk.......	2.83	....	2.12	3.18	3.30	4.80	7.20	....	....	....	109.3	180.0
	Summer of 1905—												
Lot 1	Grain	4.01	....	....	....	9.04	9.28	13.92	....	....	....	100.0	149.3
Lot 2	Grain and skim milk	2.92	....	....	8.76	5.29	7.48	11.22	....	....	12.4	92.1	160.6
Lot 3	One-half grain ration	3.00	....	....	....	4.52	6.24	9.36	....	....	....	140.0	201.7

which to make such a calculation it is put as stated. The true basis upon which to figure the value of those supplementary foods is to figure the amount of grain that would be saved by feeding these supplementary feeds. In this test, however, through the neglect of the attendant in getting the weights of the hogs fed on grain alone we cannnot make the comparison that would tell us the saving in grain by feeding the hay and the roots.

In the columns headed the value of the grain fed and the value of the gain at 4 and 6 cents per pound it has been attempted to show the comparative returns from the feeding test. It will be noticed that in no case, at 4 cents per pound for the gain made, did this gain pay the market prices for the grain fed, neglecting altogether any return on the roots or the hay. At 6 cents per pound there was a substantial return for the grain; but when we deduct from this the estimated value of the roots and the hay we find as is given in the last column of the table that even at 6 cents per pound the hogs fed in the outside run did but little more than pay for the grain given them. The comparative results in this connection are similar to those above referred to.

The conclusion to be drawn from this test seems to be that hogs will make better use of their feed when they have a chance to exercise than when confined in very small pens that allow for no exercise.

THE SECOND EXPERIMENT.

INTRODUCTION.

The second experiment of this series was conducted during the fall of 1904 from the middle of October to the middle of January. The purpose of this test was to compare the feeding value of grain along with a grain ration supplemented by skim milk and clover hay. The pigs were about 4½ months of age, all high grade Berkshires. They averaged about 90 pounds each at the beginning of the test and about an equal number of sows and barrows were in each lot. Before starting on this experiment these pigs had the run of the pasture which contained considerable clover and had in addition a small grain ration. They were a thrifty, growing lot of pigs. The grain fed consisted of two-thirds barley and one-third bran and the hogs were given all they could eat of this ration. The test contin-

ued for 98 days or little over three months. The hogs were fed in pens with an outside run during the whole time of the test. It will be noted that the hogs fed with skim milk ate the least grain. Those fed on grain alone ate the next larger amount of grain of the hogs in this test. It would seem that the addition of clover in a measure stimulated the appetite of the hogs as in addition to eating 485 pounds of clover these hogs ate 221 pounds more grain than did the lot fed on grain alone. The result of this will be seen in the gains made.

THE GAINS MADE.

Each hog in lot 1 fed on grain alone gained 92 pounds. When clover hay was added to the ration as in case of lot 3 the gains made were 110 pounds for each hog or 18 pounds more than the gain made by lot 1 on grain alone. When skim milk was added to the ration each hog gained 139 pounds which was 47 pounds more than the gains made by each hog fed on grain alone during the 98 days of the test. The average daily gain per hog for lot 1 was .94 pounds. Lot 3 with the clover added to the grain ration gained .18 pounds more per day than lot 1 while lot 2 with the skim milk added to the ration gained .46 pounds or nearly ½ pound more per day than the gains made without the skim milk ration.

POUNDS OF FOOD FOR ONE POUND OF GAIN.

The ration of skim milk and grain, figured on the basis of the amount of food required for each pound of gain, is very much the most efficient ration. 9.46 pounds of skim milk saves 2 pounds of grain as this lot required 2 pounds less grain for each pound of gain than did the hogs fed on grain alone. This is certainly a very important saving. The hogs fed on clover with the grain ration required 4.9 pounds of grain for each pound of increase in live weight and .88 pounds of hay saved .46 pounds or nearly ½ pound of grain as compared with the ration of grain alone.

THE RETURNS FROM THE FEEDING.

The table shows that when the hogs sold at 4 cents a pound the gain made on lot 1, fed grain alone, and on lot 3 fed on grain and clover hay did not pay market prices for the grain fed. The skim

milk ration ,however, gave a substantial margin above the market price of the grain given them. At 6 cents a pound for the gain the returns were substantial and a good price was obtained over and above the cost of the grain. Considering the returns for the grain per hundred pounds, after deducting the value of the supplementary feed, we find that at 4 cents per hundred pounds for the gain but 74 to 77 cents was obtained for the grain feed. With hogs at 6 cents a pound, however, the price obtained for the grain was from $1.11 to $1.23 per hundred pounds which was a very good farm price for the grain. The hogs fed with skim milk gave the largest price for the grain. Those receiving the clover hay the next and the ration of grain alone gave the poorest returns. In estimating these returns the skim milk is valued at 15 cents per hundred pounds and the hay at $5.00 per ton

The correct value however, of the hay and skim milk is figured from the amount of grain saved by adding the supplementary food. 100 pounds of hay saved 52.3 pounds of grain which would make the hay worth about $10.00 per ton as hog feed when fed with a grain ration. 100 pounds of skim milk saved 21 pounds of grain which would make the skim milk worth about 21 cents per hundred pounds when fed with grain. This estimate is based upon grain at 1 cent per pound and it shows a high feeding value for the supplementary foods.

EXPERIMENT NUMBER THREE.

INTRODUCTION.

This experiment was started soon after the close of the previous one and ran from March to June 1905. The purpose of this test was similar to the previous one but sugar beets as a supplementary food were fed. The pigs in this experiment averaged about 5 months of age. Previous to the test they had been fed a light ration of grain and skim milk. The 16 hogs were divided into four lots with four in a lot. They consisted of Berkshires, Poland Chinas, and Yorkshire grades and were quite a thrifty lot of pigs. The grain consisted of barley and bran at the same proportions as in the previous test. The roots were mainly sugar beets. The hay fed in this test was rather course and was not eaten by the hogs

as readily as in the previous test. The experiment ran for 81 days or nearly three months, the hogs being fed in pens with a small outside run. During this test the lots fed on clover and sugar beets did not receive quite all the grain they would have eaten. By reducing on the grain we tried to get them to eat a larger proportion of the supplementary food. We cannot therefore in this test note the stimulating effect of these foods on the appetites of the animals. The lot fed on grain alone ate nearly 200 pounds of grain more than the lots fed on skim milk and sugar beets and 150 pounds more than the lot fed the clover hay.

THE GAINS MADE.

These pigs at the beginning of the experiment averaged from 82 to 86 pounds each. Those fed on the ration with clover hay gained 73 pounds each, the lowest gains of any lot in the test. The hogs fed skim milk with the grain gained 110 pounds each which was the largest gain made by any lot. Those pigs fed on grain alone gained 74 pounds each which was one pound more than the gains made by lot 3 fed clover. Lot 4 fed sugar beets with the grain made 94 pounds each which was next to lot 2 the largest gains made. The gains made per day show the same result. There is but little difference between the gains made by the hogs fed on grain alone and those with grain and clover—about .01 of a pound per day. The hogs fed on sugar beets gained 1.09 pounds and those fed skim milk with the grain gained 1.34 pounds per day which was quite a substantial increase over any of the other results.

POUNDS OF FOOD FOR ONE POUND OF GAIN.

In this test as in the second experiment the hogs on grain alone required the most grain for each pound of gain, namely; 5.21 pounds grain for each pound of increase in live weight. The skim milk ration as in previous tests proved to be the most efficient, requiring but little over three pounds of grain and 8.44 pounds of skim milk for each pound of gain. This was over two pounds of grain less than was required by lot 1 fed on grain alone. The lot fed with roots made the second best returns requiring but 3.76 pounds of grain and 3.8 pounds of roots to produce one pound of increase ir

live weight. The lot receiving the clover required 4.83 pounds of grain and ate also 1.13 pounds of clover for each pound of gain.

THE RETURNS FROM THE FEEDING.

Considering first the value of the grain as compared with the value of the gain we find that when the hogs were sold at 4 cents per pound the value of the gain does not pay for the grain given lots 1 and 3, if we disregard the value of the supplementary food. With the value of the supplementary food deducted the return per hundred pounds of grain averaged about 77 cents for lots 1 and 3 and 86 to 89 cents per hundred pounds for lots 2 and 4. If the hogs were sold at 6 cents per pound the returns for the grain after paying for the supplementary food ranged from $1.15 per hundred pounds to $1.51 per hundred pounds of grain. The lots with skim milk gave the largest return, viz: $1.51 per hundred pounds for the grain following with the lot fed roots which returned $1.39 per hundred pounds for the grain. Then the lot fed clover returned $1.18 per hundred pounds, while the lot fed grain alone returned but $1.15 per hundred pounds for the grain fed.

Considering next the pounds of grain saved by one hundred pounds of hay, roots or skim milk, we find that the supplementary food had quite a high value. This is the only safe basis of comparison and for this reason deserves especial notice. 100 pounds of clover hay saved 32.7 pounds of grain, or with grain worth 1 cent per pound this makes the 100 pounds of hay worth 32.7 cents or $6.54 a ton. 100 pounds of sugar beets saved 38 pounds of grain which at the price stated for grain makes the beets worth $7.60 per ton as hog feed. 100 pounds of skim milk saved 25.2 pounds of grain which would mean a value of 25.2 cents per hundred pounds for this feed. As grain will vary considerably in price, however, the safe plan is probably to disregard the money equivalent and consider the pounds of grain saved as the basis of comparative value.

THE SUPPLEMENTARY TEST.

When the hogs in the lots 2 and 4 of the third experiment were sold those in lots 1 and 3 were not ready for the market and so were

fed 17 days longer on a ration of grain, skim milk, and sugar beets. In the 17 days the hogs gained 30 to 31 pounds each or a little over 1¾ pounds per day. The skim milk is a very palatable ration for hogs and they eat it greedily. An average of 2¾ pounds of grain, 2 pounds of roots, and 3 pounds of skim milk produced 1 pound of gain. Less than 3¼ pounds of dry matter in the food produced 1 pound of increase in live weight. It will be noticed too that for this period the hogs paid a high price for the grain given them, viz. $1.80 to $1.90 per one hundred pounds when they sold at 6 cents per pound.

This supplementary test teaches one very important fact. If hogs have been fed on a ration of grain alone and it seemed necessary to hurry them to get them fat for market earlier than was first planned, a ration of skim milk and grain, or skim milk, roots and grain will put gain on a hog faster than any feed we have tested. Such are the teachings of this test and of several others that the writer has made on this point.

THE FOURTH EXPERIMENT.

INTRODUCTION.

This test ran during the summer from the middle of June to August. The purpose of this test was similar to the previous ones but a new element enters into the result, namely; pasture. We had thus, as will be noted from the table, one lot with a full ration of grain on pasture and one lot with a half grain ration on pasture. This half grain ration was figured by feeding these hogs one-half the grain fed to the first lot getting grain alone on pasture. The hogs in lot 1 and 3 were a Yorkshire-Berkshire cross and were five months old. The pigs in lot 2 were Poland Chinas and about eight months old. The lots it will be noted, thereore, were uneven, but 1 and 3 were of similar quality and size and it is between those that the important comparison is made. Lot 2 being heavier were under some disadvantage, the larger pigs being more costly to feed. Previous to the test these hogs had been running on the pasture with a small grain ration. The grain fed during this test was similar to that fed in previous tests in the proportion of 2 of barley to 1 of bran. The pasture was a mixed grass pasture but it was not

very good, the clover having been killed out during the past winter. The hogs were fed for 55 days or nearly two months. It will be noted from the table that the hogs in lot 3 had just one-half the grain of those in lot 1. The hogs in lot 2 ate 273 pounds of grain each, compared to 311 pounds eaten by the hogs in lot 1 so that though larger the hogs fed the skim milk ate considerably less grain than those fed grain alone.

THE GAINS MADE.

At the start of this test the hogs in lot 1 and 3 averaged about 90 pounds each and the hogs in lot 2 averaged about 113 pounds each. In the 44 days the hogs in lot 1 gained 77 pounds each or 1.41 pounds per day. Those in lot 3, on the one-half grain ration, gained 52 pounds each or about 25 less than lot 1. It appears, therefore, that one half the grain ration gave two-thirds as much gain as the full grain ration. The hogs in lot 2 fed skim milk with the grain gained 93 pounds each, or 1.7 pounds per day, a very rapid gain considering the length of the feeding period. It will also be noted that the hogs fed the full grain ration on pasture gained much more rapidly than the hogs fed a similar ration in pens, as will be noted by comparing this result with experiments two and three. The same result is also true of the hogs fed the ration of skim milk and grain although the difference is not so great.

POUNDS OF FOOD FOR ONE POUND OF GAIN.

The point here to particularly note is the efficiency of the half grain ration on pasture. These hogs ate slightly less than 3 pounds of grain each per day and gained but little less than 1 pound per day. They required but 3 pounds of grain to make one pound of increase in live weight. This, if we disregard the pasture, is the most efficient gain made in this series of tests. The lot receiving skim milk and grain required less grain for each pound of gain than did lot 3 but ate 8.73 pounds of skim milk which more than made up the difference. Lot 1 on grain alone required four pounds of grain for each pound of gain. This though more expensive than the other lots in this test, yet was an average of 1¼ pounds of grain less than was required by the hogs in the previous tests reported when

the hogs were fed grain in pens. The supplementary food obtained from the pasture enabled the hogs to do much better than those fed grain alone in the pens.

THE RETURNS FROM THE FEEDING.

In this test, every lot, even if sold for 4 cents per pound, returned a margin over the cost of the grain at market prices. At 6 cents per pound this increase was more than double the market price of the grain fed. The largest marginal profit is, as will be noted, from the half grain ration. Considering the returns for the grain per hundred pounds, after allowing for the value of the skim milk, we notice that when the hogs were sold at 4 cents per pound the hogs fed skim milk returned 92 cents per hundred pounds for the grain. Those fed on grain alone returned $1.00 per hundred pounds and those fed the half grain ration returned $1.40 per hundred pounds. At 6 cents a pound for the increase on the hogs, the full grain ration on pasture paid $1.49 per hundred pounds for the grain. This is the largest return obtained from any lot fed on a full grain ration in this series of tests except where skim milk was fed and shows the benefit of the pasture as compared to the pen feeding. The most interesting result is with the hogs fed the one half grain ration on pasture. At 6 cents per pound for the hogs we get a return of $2.02 per hundred pounds for the grain fed. This is the largest return for the grain of any of the lots tested even with those given supplementary food. When fed a part grain ration the hogs seem to make a larger use of the pasture and get much more good from it. The only disadvantage to this method of feeding is that the gains are slower, these hogs making but two-thirds the gain made by lot 1 on the full grain ration. It would then take them one-third longer to get them ready for market which might carry them beyond a good to a time of a lower market price. The feeders should keep these facts in mind and be guided accordingly.

A CONCLUSION.

A point of considerable importance is that this result indicates that when running on pasture, hogs will keep in good condition and even gain in live weight on a light grain ration. There are yet many other facts however, to be worked out along the lines of this test.

The important point brought out in this test is the value of some supplementary food added to the grain ration in fattening hogs. In these tests no peas have as yet been fed but with the other grains, the best results cannot be obtained without some supplementary food. In these tests, skim milk, sugar beets, clover or alfalfa have been used and their value seems to be in the order named. It is apparent that in some way these additional foods have a value beyond what their composition would indicate. These supplementary foods seem to act in two or three ways. 1st they seem to stimulate the appetites of the animals so that they eat more of the grain and make more economic gains because there is a larger surplus over the requirements of the body to turn into meat. 2nd, these supplementary foods may aid the digestion of the hogs so that they can make better use of the food given them.

Why the hogs fed the half grain ration gained so rapidly is probably due to the fact that when they did not get as much grain as they would eat, they ate much more of the pasture and thus obtained much more feed in this way than, would the hogs on the full grain ration.

It should not be forgotten in this connection that as hogs in our local market vary considerably in price at different times of the year, that the cheapest gains, if they lengthen the time of feeding, may not be the most economical if the slower gains carry the hogs over a period of high to a period of low prices. The reduced price for the hogs may destroy all the profit arising from the cheaper gains made.

SUMMARY.

(1). These tests seem to show that when feeding grain to fatten hogs some supplementary food is needed to get the best returns from the grain.

(2). Considering all the experiments the value of the supplementary food is in the following order, namely: 1st, skim milk; 2nd, roots; 3d pasture; 4th clover or alfalfa.

(3). After deducting the estimated value of the supplementary food, in none of these tests did the hogs return market prices for the feed when they were sold for 4c per lb. live weight. The range was from 74c to 92c excluding the first experiment. If sold at 6c per lb., the returns on the feed was substantial, ranging from $1.80 to $1.90 per 100 lbs.

(4). Leaving out the experiment conducted during 1903 and the supplementary test, it required according to these experiments the following amounts of food for each 100 lbs. of gain:

On grain alone .... 528 lbs. grain
On grain and Clover.... 487 lbs. grain and 200 lbs. clover
On grain and pasture . 401 lbs. grain
On grain and roots ......376 lbs. grain and 280 lbs. roots
On grain and skim milk..311 lbs. grain and 888 lbs. skim milk
On ¼ grain ration and
pasture ....300 lbs gain

(5). The value of these supplementary foods as given in this bulletin is figured from their value when fed with a full grain ration, except in one case. What the value of these foods would be when fed in some other way, is a question these tests furnish us no light upon.

Notice: A few of the early issues of the Bulletins of the Montana Experiment Station are completely exhausted. We would like very much to get copies of Bulletin Nos. 21, 26, 27, 29 and 31. Any person who has copies of these bulletins would confer a great favor if they would let us know and we will send postage for their return.

Very truly,

F. B. LINFIELD, Dir.

Montana Agricultural College Experiment Station

F. B. LINFIELD, DIRECTOR

BULLETIN NO. 58

FATTENING CATTLE

FOR THE YEARS 1904 AND 1905

BY

F. B. LINFIELD

Animal Industry

BOZEMAN, MONTANA

OCTOBER

1905

MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION

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STEER FEEDING EXPERIMENT, 1903-4.

INTRODUCTION.

The feeding tests with the car load of steers was again taken up during the winter of 1903-4. We were somewhat late in getting the animals, so that they were put immediately into the feeding yards upon their arrival at the college farm. 32 head of steers were fed. They ranged in age from two to three years and were an average lot of range steers, though nothing extra as to quality. They were purchased from two or three farmers in the neighborhood of Bozeman and cost an average of a little over three cents per pound live weight. Some of the steers were dehorned when purchased, but about half the lot were dehorned just before the test started.

PURPOSE AND PLAN OF THE TEST.

This experiment was arranged as a continuation of the experiment of the year before, namely, to test the feeding value of the different kinds of grain and combinations of grain which are available to the Montana farmer. The steers were divided into four lots, 8 steers in each lot, our aim being to divide these steers as evenly as possible according to weight and quality. The lots were fed as follows:

Lot I received clover hay and crushed wheat as a grain ration. Lot II received clover hay, and ground oats as the grain ration. Lot III received clover hay, and ground barley as a grain ration, and lot IV received clover hay and a mixture of grains consisting of equal parts of wheat, oats and barley. The clover part of the ration consisted of the first and second crops and was a very fair quality of clover. The grain was good sound grain. It was chopped medium fine and was in good condition for feeding. The

experiment started on December 21. For the first six to eight days hay alone was fed. Then we started with the grain, gradually increasing the amount until at the end of three weeks the full grain ration of 5 pounds per day per steer was fed. The hay was fed twice a day. The grain at first was fed once a day, but later, when a larger quantity was fed, they received the grain twice a day. The steers had water and salt where they could get to it at any time. The steers were weighed three days in succssion at the beginning of the test and every two weeks thereafter until the close of the test, when they were again weighed three times in succession. The average of these weights was taken as the average weight of the steers. The cost of the feed was as follows: Clover hay, $5.00 per ton; wheat, $1.25 per hundred pounds; oats, $1.00 per hundred pounds; barley, $1.00 per hundred pounds; bran, 85 cents per hundred pounds. These were about the average prices in the Gallatin valley for that year.

The steers were fed in yards which sloped to the west. These yards were about 25 feet by 150 feet. At one end of these yards was a straw covered shed, about 25 by 20 feet, into which the steers went nearly every night. These sheds and yards were kept bedded with straw so as to give the animals as comfortable quarters as possible. The hay and grain were fed in racks and troughs outside in the yards. The steers, when first put into the yards. were somewhat restless, but they soon quieted down. They were not familiar with grain and had at first to be coaxed to eat it.

THE GAINS MADE.

Table No. 1 gives the weights and gains of the steers. This table is divided into periods, so as to permit a study of the gains during the progress of the test. Considering the whole time of the test, 101 days, it will be noticed that the steers gained 218 pounds each, increasing from 935.8 to 1153.8 pounds, which was an increase of 2.16 pounds per day, a very satisfactory gain, considering the length of the test. There is not very much to notice in the gains made in the first, second and third periods. For the fourth period all of the animals made proportionately better gains than they did at any other time. Considering the two periods, from Jan. 13 to March 8, which might be called the test period and continued for 65 days, it will be noticed that the steers fed on the mixed grain ration made the largest gains per day, namely, 2.23 pounds. The barley ration gave the next largest gain, namely,

TABLE No. 1—WEIGHTS AND GAINS OF STEERS, 1903-4.

PERIOD.	Lot	HOW LOTS WERE FED.	Weight beginn'g of exper. and of each period	Weight at end of period and of test	Gain f'r each period and tot' Gain.	Aver'g daily gain per steer.	Aver'e gain per steer
1st peroid, Dec. 21 to Jan. 12, 23 days	1	Clover hay and wheat..........	7458	7755	297	1.61	37.1
" " " "	2	Clover hay and oats............	7547	7925	378	2.06	47 3
" " " "	3	Clover hay and barley..........	7417	7780	363	1.98	45.5
" " " "	4	Clover hay and mixed Grain....	7527	7912	385	2.10	48.2
2d period, Jan. 13 to Feb. 19, 38 days	1	Clover hay and wheat..........	7755	8410	655	2.12	81.8
" " " "	2	Clover hay and oats............	7925	8522	597	1.96	74.6
" " " "	3	Clover hay and barley..........	7780	8485	705	2.32	88.1
" " " "	4	Clover hay and mixed Grain....	7912	8625	713	2.34	89.1
3d period, Feb. 20 to Mar. 8, 18 days	1	Clover hay and wheat..........	8410	8712	302	2.10	32.6
" " " "	2	Clover hay and oats............	8522	8805	283	1.96	35.2
" " " "	3	Clover hay and barley..........	8485	8760	275	1.91	32.
" " " "	4	Clover hay and mixed Grain....	8625	8910	285	1.98	26.8
4th period, Mar. 9 to Mar. 30, 22 days	1	Clover hay and wheat..........	8712	9123	411	2.33	56.5
" " " "	2	Clover hay and oats............	8805	9233	428	2.43	53.5
" " " "	3	Clover hay and barley..........	8760	9138	378	2.15	49.6
" " " "	4	Clover nay and mixed Grain....	8910	9430	520	2.95	73.7
Two periods, Jan. 13 to Mar. 8, 56 days	1	Clover hay and wheat..........	7755	8712	957	2.13	119.6
" " " "	2	Clover hay and oats............	7925	8805	880	1.96	110.
" " " "	3	Clover hay and barley..........	7780	8760	981	2.19	122.5
" " " "	4	Clover hay and mixed Grain....	7912	8910	998	2.23	124.7
Whole time, 101 days...............	1	Clover hay and wheat..........	7458	9123	1665	2.06	208.1
" " " "	2	Clover hay and oats............	7546	9233	1687	2.09	210.8
" " " "	3	Clover hay and barley..........	7416	9138	1722	2.13	215.2
" " " "	4	Clover hay and mixed Grain....	7526	9430	1904	2.35	238.0
Average for 32 steers..................		....	29946	36924	6978		
Average for 1 steer....................		....	935.8	1153.8		2.16	218.0

2.19 pounds per day, or 122.5 pounds on each steer. The wheat ration gave the next largest gain, with 2.13 pounds per day and 119.6 pounds for each steer. The oat ration gave a gain of 110 pounds for each steer—the lowest gains made. Considering the whole time of the experiment, which will include the first period, when no grain was fed, the mixed grain ration again gives the largest gain, 2.35 pounds per day or 238 pounds on each steer. The barley ration comes next, giving a return of 2.13 pounds per day or 215 pounds per steer. The oat ration comes third, with 2.09 pounds of gain per day and 210.8 pounds for each steer. The wheat shows a gain of 2.06 pounds per day and 208.1 pounds for each steer for the whole time of the test. For the test period, during which the steers were on a full grain ration, it will be noticed that the steers fed on the oat ration made the slowest gains. This corresponds with the results of the year before, as is noted in table No. 2. On March 9 the grain of all the cattle was changed to mixed grain and continued for 22 days. This mixed grain consisted of ½ barley, ¼ oats and ¼ bran. It will be noticed that for this period the steers gained more rapidly than at any other time durin the test, and that the steers fed previously on the oat ration, next to the steers fed the mixed grain ration, gained more than those that had been fed wheat or barley.

From table No. 2 it is interesting to note the close comparison between the results of this year and the previous year on the same ration. The average for the car lot was 2.15 pounds per day for 1903 and 2.16 for the year 1904.

TABLE No. 2.—A Comparison of the daily Gain, per Steer, for 1903 and 1904.

Days Fed. 1903—111 days.. 1904—101 days..	Lot 1. Fed wheat. lbs.	Lot 2. Fed Oats. lbs.	Lot 3. Fed Barley. lbs.	Lot 4. Fed Mixture lbs.	Average for Car lot. lbs.
1903 gain per day	2.10	1.69	2.34	2.53	2.15
1904 gain per day	2.06	2.09	2.13	2.35	2.16
Average......	2.08	1.89	2.24	2.44	2.16

FOOD EATEN PER DAY AND FOR ONE POUND OF GAIN.

Table No. 3 gives the total food eaten by each lot for the various periods, and also the food eaten per day for each pound of gain, and the cost of this feed. Considering the whole time of the test, 101 days, we find that each steer ate on the average 2391 pounds of clover and 455½ pounds of grain. During the first period it will be noticed that the steers ate very lightly of both the clover and the grain, eating but 19.6 pounds of clover and about 2½ pounds of grain.

The second period the steers ate more largely of the clover, increasing the daily ration to 23.4 pounds and the grain to five pounds per day. The third period there was again an increase in hay to 27.1 pounds with the 5 pounds of grain. The fourth period the steers dropped 1½ pounds per day on the hay eaten.

Considering next the food eaten for each pound of gain we find that on the average it required 10.97 pounds of hay and 2.09 pounds of grain for each pound of increase in live weight. This was the average for the 32 steers. Considered by lots the food for each pound of gain ranged from 10 pounds of hay and 1.83 pounds of grain up to 11½ pounds of hay and 2.15 pounds of grain. Considering the whole time of the feeding the steers fed the mixed grain made the most economic gains. The barley comes next, followed by the oat and wheat rations. Considering, however, the test period of 56 days, which is the correct basis of comparison, the oat and wheat rations change places, the oat ration being the most expensive, requiring 12½ pounds of hay and 2.55 pounds of grain to produce 1 pound of increase in live weight. During the first period when fed upon the light grain ration the steers gave the best average results considering the amount of food eaten. Probably, however, this might have been partly a filling process and will not therefore afford as just a comparison as later feeding. Next to this comes the fourth period when a mixed grain ration was fed. Here we find that the range was from 8.8 pounds of the clover and 1.7 pounds of grain, to 11.9 pounds of clover and 2.33 pounds of grain, to produce each pound of increase in live weight. These results are very satisfactory from the standpoint of economic production.

LE No. III.—FOOD EATEN BY STEERS AND COST OF SAME, 1903-4.

PERIOD.	Lot.	How Lots Were Fed.	Total Food Eaten.		Food eaten per day per steer		Food eatn for one lb. gain.		Cost of Feeding.	
			Clover lbs.	Grain lbs.	clov'r lbs	grain lbs	clo'r lbs.	gr'n lbs.	per day p'r st. cts.	per 1 lb. gain. cts.
1st period Dec. 21 to Jan. 12, 23 days	1	Clover hay and wheat........	3600	465	19.6	2.53	12.1	1.56	7.50	4.68
" " " " "	2	Clover hay and oats..........	3600	465	19.6	2.53	9.5	1.23	7.50	3.68
" " " " "	3	Clover hay and barley........	3600	465	19.6	2.53	9.9	1.28	7.50	3.84
" " " " "	4	Clover hay and mixed grain..	3600	465	19.6	2.53	9.3	1.21	7.50	3.62
2d period, Jan. 13 to Feb. 19, 38 days	1	Clover hay and wheat........	7105	1520	23.4	5.	10.8	2.32	12.10	5.60
" " " " "	2	Clover hay and oats..........	7105	1520	23.4	5.	11.9	2.55	10.85	5.52
" " " " "	3	Clover hay and barley........	7105	1520	23.4	5.	10.1	2.15	10.85	4.67
" " "	4	Clover hay and mixed grain...	7105	1520	23.4	5	9.9	2.18	11.30	5.10
20 to Mar. 8, 18 days	1	Clover hay and wheat........	3910	720	27.1	5.	12.9	2.38	13.02	6.20
" " "	2	Clover hay and oats..........	3910	720	27.1	5.	13.8	2.54	11.77	5.99
" " "	3	Clover hay and barley........	3910	720	27.1	5.	14.2	2.82	11.77	6.17
" " " "	4	Clover hay and mixed grain...	3910	720	27.1	.5	13.1	2.52	12.22	6.17
...d period, Mar. 9 to Mar. 30, 22 days	1	Clover hay and wheat........	4520	880	25.7	.5	11.	2.14	11.52	4.93
" " " " "	2	Clover hay and oats..........	4520	880	25.7	.5	10.5	2.05	11.52	4.75
" " " " "	3	Clover hay and barley........	4520	880	25.7	.5	11.9	2.33	11.52	5.35
" " " " "	4	Clover hay and mixed grain...	4520	880	25.7	.5	8.8	1.70	11.52	3.93
Two periods, Jan 13 to Mar. 4, 56 d'ys	1	Clover hay and wheat........	11015	2240	24.6	.5	11.5	2.33	12.40	5.78
" " " " "	2	Clover hay and oats..........	11015	2240	24.6	.5	12.5	2.55	11.15	5.67
" " " " "	3	Clover hay and barley........	11015	2240	24.6	.5	11.2	2.28	11.15	5.08
" " " " "	4	Clover hay and mixed grain...	11015	2240	24.6	.5	11.	2.25	11.60	5.20
Whole time, 101 days.............	1	Clover hay and wheat........	19135	3585	23.7	4.43	11.5	2.15	11.09	5.33
" " " " "	2	Clover hay and oats..........	19135	3585	23.7	4.43	11.3	2.12	10.40	5.01
" " " " "	3	Clover hay and barley........	19135	3585	23.7	4.43	11.1	2.08	10.40	4.86
" " " " "	4	Clover hay and mixed grain...	19135	3585	23.7	4.43	10.	1.83	10.64	4.56
Total 32 steers		....	76540	14240						
Average, 1 steer		....	2391.2	455.5	23.7	4.43	10.97	2.09	10.63	4.94

Comparing, next, these results with those of the year before, we get table No. 4. This table is classified so as to compare the results for the experiment period and also for the whole time of the test. It will be noticed that for the experiment period the oat ration in both years gave the poorest results, requiring the most food for each pound of gain. The mixed grain ration, on the other hand was the most efficient ration for both years. For 1903 the wheat ration proved a little superior to the barley ration and in 1904 the converse of this was the result. Considering the average for the two years we find that in 1903 it required 15.3 pounds of hay and 2.61 pounds of grain for each pound of gain. In 1904, 11.5 pounds of hay and 2.35 pounds of grain were eaten for each pound of gain, so that a little more economic gains were obtained during the winter of 1904.

TABLE No. IV.—A Comparison of the Food Eaten for one Pound of Gain During 1903 and 1904.

Experim't period. 49 days, 1903 56 days, 1904	Lot 1. Fed Wheat. lbs.		Lot 2. Fed Oats. lbs.		Lot 3. Fed Barley lbs.		Lot 4. Fed Mixture lbs.		Average of Car Lot. lbs.	
	Hay	Gr'n	Hay	Gr'n	Hay	Gr'n	Hay	Gr'n	Hay	Gr'n
Food for 1 lb. of gain, 1903.....	13.	2.06	20.2	3.54	15.1	2.68	12.8	2.27	15.3	2.61
Food for 1 lb. of gain, 1904.....	11.5	2.33	12.5	2.55	11.2	2.28	11.	2.25	11.5	2.35
Average.........	12.2	2.19	16.3	3.04	13.1	2.48	11.9	2.26	13.4	2.48
Whole time of t'st 111 days, 1903 101 days 1904										
Food for 1 lb. of gain, 1903.....	13.1	1.85	16.3	2.42	12.3	1.83	10.9	1.62	12.8	1.9
Food for 1 lb. of gain, 1904.....	11.5	2.15	11.3	2.12	11.1	2.08	10.	1.83	10.97	2.09
Average.........	12.3	2.00	13.8	2.32	11.7	1.95	10.4	1.72	11.88	1.99

Considering, next, the whole time of feeding, again a close relation between the results of the two years is apparent. On the average in 1903 it required 12.8 pounds of hay and 1.9 pounds of grain for each pound of gain, and in 1904 it required 10.97 pounds of hay and 2.09 pounds of grain for each pound of increase in live weight.

COST OF FEEDING.

Considering, next, the cost of feeding, we find that on the average it cost 10.63 cents per day to feed each steer. The range for the different lots was from 10.4 cents per day for the oat and barley ration to 11.09 cents per day for the wheat ration. As noted in other publications the cost is not always a true test of the feeding value of any grain; the amount of food required for each pound of gain being a much more correct test upon which to base conclusions. The wheat ration in this respect is the most costly because of the greater value of the wheat, which was $1.25 per hundred pounds, compared with $1.00 per hundred pounds for the other grains.

The cost for each pound of gain was 4.94 cents, or nearly 5 cents. The range was from 4.56 cents, or about 4½ cents, up to 5 1-3 cents for each pound of gain. The mixed grain ration was the least costly. Next follows the barley ration, the oat and wheat rations being the most expensive. The cheapest gains were made during the first period, when the light grain ration was fed. The next to the cheapest gains were made during the 4th period, when a mixed grain ration was fed.

TABLE No. V.—A Comparison of the Cost of Producing one Pound of Gain During 1903 and 1904.

Test Period. 49 days. 1903 56 days. 1904	Lot 1. Fed Wheat. Cents.	Lot 2. Fed Oats. Cents.	Lot 3. Fed Barley. Cents.	Lot 4. Fed Mixture Cents.	Average of Car Lot. Cents.
Cost of 1 lb. gain 1903..........	5.06	8.05	6.32	5.22	6.16
Cost of 1 lb. gain 1904...........	5.78	5.67	5.08	5.20	5.43
Average	5.42	6.86	5.25	5.21	5.79
Whole time exp. 111 days. 1903 101 days, 1904					
Cost of 1 lb. gain 1903..........	5.90	6.13	4.81	4.17	5.20
Cost of 1 lb. gain 1904.........	5.33	5.01	4.86	4.56	4.94
Average	5.61	5.57	4.83	4.36	5.07

Table No. 5 makes a comparison of the cost of feeding, both for the test period and for the whole time of the experiment, for two years, viz: 1903 and 1904. It will be noticed that during 1903, for the test period, the cheapest gains were made by the wheat ration. But that year the wheat was worth less than it was

during 1904. On the average for all of the steers it cost 6.16 cents for each pound of gain for 1903 and for 1904 the cost was 5.43 cents. For the whole time of the feeding test it cost during 1903, 5.2 cents, on the average, for each pound of gain put upon the steers. During 1904 the cost was 4.94, or nearly .3 cents less. The cheapest gains in both years were made with the mixed grain ration. In 1903 this ration produced a pound of gain for 4.17 cents, and in 1904 the cost was 4.56 cents.

TABLE No. VI—FINANCIAL RESULTS AND SUMMARY, 1903-4.

	Lot I Wheat	Lot II. Oats.	Lot III Barley	Lot IV Mix're	Average & totals.
Number of Steers	8	8	8	8	32
Weight at beginning ..... lbs.	7458	7546	7416	7526	29946
Cost of steers at 3.2c. per pound	$236.60	$239.38	$235.27	$238.75	$950.00
Cost of food per lot	89.60	84.03	84.03	85.97	343.63
Cost of food per steer	11.20	10.50	10.50	10.74	10.73
Total cost of steers	326.20	323.41	319.30	324.72	1293.63
Weight at close of experiment ..... lbs.	9123	9233	9138	9430	36924
Rec'd for steers, 3.5c lb shrunk w'ght	308.47	312.20	313.56	318.90	1253.12
Received per head for each steer	38.56	39.02	39.19	39.86	39.16
Loss on each lot	17.73	11.21	5.74	5.82	40.51
Loss on each steer	2.21	1.40	.72	.73	1.26

FINANCIAL RESULTS WITH STEERS.

Table No. 6 gives the financial results with this lot of steers. As noted above the steers made better gains, and, comparatively speaking, more economical gains, during the time of this test than they did the year before. However, financially considered, the results did not return enough to pay for the feed given the animals. These steers cost an average of 3.2 cents per pound live weight. They were sold for 3½ cents per pound shrunk weight. This meant slightly less than $40.00 per head net received for each steer and meant a loss on the whole lot of $40.51. This was an average of $1.26 loss on each steer, or, in other words, the steers failed to pay for the feed given them, without considering the labor, by $1.26 each. This result bears out the statement of the year before that profits in feeding steers cannot be generally made unless there is a greater difference in the buying and selling price than was the case with this car lot. I think others will remember that during this year (1903) many steers sold in the market for a lower price in the spring than they did in the fall, and with very many people the losses were greater than are here shown.

STEER FEEDING EXPERIMENT, 1904-5.

INTRODUCTION.

In an agricultural country, such as Montana is, there are many agricultural and live stock questions pressing for solution, and it is difficult at times to decide which of these should have first attention. The first experiments conducted at the Station on feeding cattle were conducted by Prof. Shaw during the three years from 1900 to 1902. These experiments dealt mainly with the feeding value of the different kinds of fodders. The next two years these experiments were conducted by the writer in a study of the comparative value of different kinds of grain. The results of the two years' work were very similar, so that while these results are not exactly conclusive, yet they afford a guide for those interested, and are valuable as a basis for further study.

Another question that has attracted much attention and considerable inquiry is, as to the amount of grain to feed with the fodder crops, clover and alfalfa. This question is of considerable importance as our fodder crops are comparatively cheap, whereas the grain is much more expensive than in the east. Because of this fact we determined during the winter 1904-5 to consider the question of the amount of grain that might be most profitably fed in a fattening ration. For this test we had on the station farm three steers, and 21 head were purchased from Mr. John Keifer, of Bozeman. The steers were a fair average lot, but not extra in quality. consisting of Hereford and Shorthorn grades. They weighed on the average 1070 lbs. each when they arrived on the station farm Nov. 9, 1904. They had the run of a pasture but were also fed hay in racks in addition until November 21st, when the experiment was started.

PLAN OF THE EXPERIMENT.

The twenty-four steers were divided into four lots and the division was made as evenly as possible, considering weight and quality. There were thus six steers in each lot. These steers were fed as follows: Lot one was fed on clover

hay and three pounds of grain a day. Lot two was fed on clover hay and five pounds of grain a day. Lot three was fed on clover hay and seven pounds of grain a day. Lot four was fed on clover hay and 10 pounds of grain a day. The hay fed was a mixture of first and second crops clover, and of fairly good quality. The grain ration was made up of a mixture of barley, oats and bran, in the proportion of ½ barley, ¼ oats and ¼ bran by weight. For the first two weeks of the test the cattle received clover hay only. The grain ration was then started by giving six pounds of grain to each lot, or one pound to each steer. This grain ration was increased one pound to each lot every second day until a full grain ration was reached. It will be seen from this that lot one, getting three pounds of grain, received its full grain ration a considerable time before the other lots received the full amount of grain specified. This gradual increase in the grain was necessary so that the steers would get used to the heavy grain ration without danger of digestion disturbances. The hay was fed to the steers twice a day, morning and evening, they being given what they would eat up reasonably clean in an hour or two. The grain was weighed to the steers at each feed, twice a day. These steers were fed in the same yards as in previous years and it was noted that they made good use of the straw covered shed during the nights, which made for them quite comfortable quarters.

COST OF THE FEED.

The cost of the feed is given to afford a comparison with other years and to give a basis for figuring the cost, by those whose prices are similar to ours. The value put upon the feed was as follows: Clcver hay, $5.00 per ton; barley, $1.05 per cwt,; oats $1.00 per cwt.; bran, 90c per cwt.

WEIGHING THE CATTLE.

To get the correct weights of the cattle they were weighed three times in as many days at the beginning of the test. They were weighed again when on full feed and once each two weeks thereafter until the close of the test. The cattle were weighed right after noon so as to be as near midway between morning and evening feeding as possible.

DISCUSSION OF RESULTS.

Tables 1 and 2 give the result of this feeding test. The time of feeding is divided into periods, to better study the results, as the experiment progressed. Each lot of steers received the same kind and quality of hay throughout the test. The only difference in the ration given was in the varying amounts of grain.

GAIN IN LIVE WEIGHT.

Table No. 1 shows the weights and gains made by the various lots. Considering, first, the experiment period of 99 days, or 14 weeks, from Dec. 20 to March 29, we find that lot II (5 pounds of grain per day) gained 536 pounds, while lot IV (10 pounds of grain per day) gained 706 pounds, or 170 pounds more. This was also 36 pounds more than was gained by lot I and 51 pounds more than was gained by lot III. The daily gains were low, compared with previous years' feeding. Lot I gained more than lot II, although lot I received less grain. Lot IV, on 10 pounds of grain, gained but 1.19 pounds per day per steer, and lot I, on three pounds of grain, gained 1.13 pounds per day per steer—a very slight difference.

Considering the experiment period the effect of the increased grain ration is seen in the increase in the gains made as the amount of grain is increased, but the difference is much less than the difference in the grain ration would lead a person to expect.

Considering, next, the whole time of the test we have a somewhat similar result. The steers in each lot gained on the average from 149 pounds for lot II to 177 pounds for lot IV and averaged for the carload 167.7 lbs. each during the 129 days of the test. The daily gain per steer ranged from 1.16 pounds per day for lot II to 1.37 pounds for lot IV. When we consider the whole of the feeding period, except for lot II, there is but little difference in the gains made by the different lots fed the different amounts of grain. Lot I received 3 pounds of grain per day per steer and gained 1024 pounds. Lot III received 7 pounds per day and gained 1037 pounds, or but 13 pounds more than lot I in 129 days Lot IV received 10 pounds of grain per day and gained 1066 pounds, or but 44 pounds more than lot I on three pounds of grain per day.

Considering each individual steer, those fed on 7 and 10

TABLE No. 1.—WEIGHTS AND GAINS OF STEERS, 1904-5.

PERIODS.	RATIONS.	Weight at commencemet of experiment and cf each period.	Weight at end of period and of test.	Gain for each period and total gain	Average daily g'n of each steer.	Average gain for each steer.
		lbs.	lbs.	lbs.	lbs.	lbs.
1st Period.						
1st period, Nov. 21 to Dec. 20, 30 days 1	Clover hay and 3 pounds grain per day	6546	6900	354	1.96	59.00
" " " " ....Lot 2	Clover hay and 5 pounds grain per day	6488	6850	362	2.01	60.33
" " " " ....Lot 3	Clover hay and 7 pounds grain per day	6553	6935	382	2.12	63.66
" " " " ....Lot 4	Clover hay and 10 pounds grain per day	6490	6850	360	2.	60.
2d period, Dec. 21 to Jan. 17, 28 days 1	Clover hay and 3 pounds grain per day	6900	7102	202	1.20	33.66
" " " " ....Lot 2	Clover hay and 5 pounds grain per day	6850	6975	125	.74	20.83
" " " " ....Lot 3	Clover hay and 7 pounds grain per day	6935	7097	162	.96	27.
" " " " ....Lot 4	Clover hay and 10 pounds grain per day	6850	6955	105	.62	17.50
3d period Jan. 17 to Feb. 14, 28 days 1	Clover hay and 3 pounds grain per day	7102	7205	103	.61	17.16
" " " " ....Lot 2	Clover hay and 5 pounds grain per day	6975	7187	212	1.26	35.33
" " " " ....Lot 3	Clover hay and 7 pounds grain per day	7097	7305	208	1.23	34.66
" " " " ....Lot 4	Clover hay and 10 pounds grain per day	6955	7210	255	1.51	42.50
4th period, Feb. 15 to Mar. 29, 43 days 1	Clover hay and 3 pounds grain per day	7205	7570	365	1.41	60.83
" " " " ....Lot 2	Clover hay and 5 pounds grain per day	7187	7386	199	.77	33.16
" " " " ....Lot 3	Clover hay and 7 pounds grain per day	7305	7590	285	1.10	47.50
" " " " ....Lot 4	Clover hay and 10 pounds grain per day	7210	7556	346	1.34	57.66
3 periods, Dec. 21 to Mar. 29, 99 days 1	Clover hay and 3 pounds grain per day	6900	7570	670	1.13	111.7
" " " " ....Lot 2	Clover hay and 5 pounds grain per day	6850	7386	536	.90	89.2
" " " " ....Lot 3	Clover hay and 7 pounds grain per day	6935	7590	655	1.10	109.2
" " " " ....Lot 4	Clover hay and 10 pounds grain per day	6850	7556	706	1.19	117.7
Whole time, Nov 21 to Mar 29, 129 d's 1	Clover hay and 3 pounds grain per day	6546	7570	1024	1.32	170.66
" " " " ....Lot 2	Clover hay and 5 pounds grain per day	6488	7386	898	1.16	149.66
" " " " ....Lot 3	Clover hay and 7 pounds grain per day	6553	7590	1037	1.33	172.83
" " " " ....Lot 4	Clover hay and 10 pounds grain per day	6490	7556	1066	1.37	177.66
Weight of 24 steers		26077	30102	4025		
Weight of 1 steer		1086.5	1254.2		1.30	167.70

pounds of grain per day gained but 2 and 7 pounds more, respectively, than those fed three pounds of grain per day, and that for the 129 days of the feeding test. Leaving out of consideration lot II, which for some reason did not do quite so well, we notice a slight increase in the gain of the steers as the grain ration is increased, but the increased gain in no wise compensates for the extra grain eaten. Neither is this gain sufficient to give the better fed steer any better finish for the market. It should be noticed, however, that the gains made by the steers in this experiment were the lowest gains made by any steers fed at the Station for the past five years. The gains by years are as follows: In 1900 the average daily gain per steer was 2.27 pounds. In 1901 it was 1.82 pounds. In 1902 the gain was 2.27 pounds. In 1903 each steer gained 2.15 pounds. In 1904 each steer gained 2.16 pounds and in 1905 the gain was 1.3 pounds per day per steer. I cannot at this time account for the difference, unless it may be due to the fact that the steers fed the past winter were in a little better flesh at the beginning of the experiment.

FOOD EATEN BY THE STEERS AND COST OF FOOD.

Table No. 2 gives the weight of food eaten by the steers and the cost of the same. Considering, first, the test period of 90 days, the steers ate per day from 22.1 to 25.7 pounds of hay and from three to 9 pounds of grain. We will notice that there is a slight decrease in the amount of hay eaten per day as the amount of grain increases, but the total food eaten is larger for those steers getting the larger grain ration. In other words, the increase in the grain ration did not save, proportionately, as large amount of hay as the increase in grain fed. The time covered by this "test period" starts when lot I received the full grain ration of 3 pounds per day, and it took one month after this to get lot IV up to 10 pounds of grain, so that the average grain fed for the "test period," except for lots I and II, is slightly below the maximum grain ration.

Considering, next, the food eaten for one pound of gain, we find that lot I ate 22.8 pounds of hay and 2.66 pounds of grain for each pound of gain made. Lot II, with 5 pounds of grain per day, required 28 pounds of hay and 5.43 pounds of grain. Lot III ate 22.5 pounds of hay and 6.02 pounds of grain for each pound of increase in live weight, while lot IV, on a maximum grain ration, required 18.6 pounds of hay and 7.53 pounds of grain for each

TABLE No. 2.—FOOD EATEN BY STEERS AND COST OF FOOD, 1904-5.

PERIODS.	LOT.	HOW LOTS WERE FED.	Total food eaten.		Food eat'n per day per steer.		Food eaten for 1 pou'd gain.		Cost of feeding	
			Lbs Clover	Lbs Grain	Lbs Clover	Lbs Grain	Lbs Clover	Lbs Grain	Cts per day Per steer	Cts per 1 lb gain.
First period.	1	Clover hay and 3 lbs of grain per day	4430	160	24.6	.88	12.5	.44	7.	3.5
Nov. 21 to Dec. 20, 30 days	2	Clover hay and 5 lbs of grain per day	4398	160	24.4	.88	12.1	.43	7.0	3.4
	3	Clover hay and 7 lbs of grain per day	4370	160	24.2	.88	11.4	.41	6.9	3.2
	4	Clover hay and 10 lbs of grain per day	4320	160	24.	.88	12.	.44	6.9	3.4
Second period.	1	Clover hay and 3 lbs of grain per day	4395	504	26.1	3.	21.7	2.50	9.6	8.
Dec. 20 to Jan. 17, 28 days	2	Clover hay and 5 lbs of grain per day	4400	782	26.1	4.65	35.2	6.28	11.4	15.3
	3	Clover hay and 7 lbs of grain per day	4390	960	26.1	5.71	27.1	5.93	12.5	13.
	4	Clover hay and 10 lbs of grain per day	4370	1055	26.	6.27	41.9	10.11	13.	21.8
Third period.	1	Clover hay and 3 lbs of grain per day	4300	504	25.9	3.	42.4	4.91	9.6	15.7
Jan. 17 to Feb. 14, 28 days	2	Clover hay and 5 lbs of grain per day	4370	840	26.	5.	20.6	3.96	11.7	9.3
	3	Clover hay and 7 lbs of grain per day	4370	1176	26.	7.	21.1	5.68	13.8	11.2
	4	Clover hay and 10 lbs of grain per day	3600	1680	21.4	10.	14.1	6.62	15.8	10.4
Fourth period.	1	Clover hay and 3 lbs of grain per day	6525	774	25.2	3.	17.9	2.12	9.4	6.7
Feb. 14 to March 29, 43 days	2	Clover hay and 5 lbs of grain per day	6255	1290	24.2	5.	31.4	6.49	11.3	14.6
	3	Clover hay and 7 lbs of grain per day	5985	1806	23.1	7.	21.	6.36	13.1	11.9
	4	Clover hay and 10 lbs of grain per day	5145	2580	19.9	10.	14.8	7.46	15.4	11.5
Three periods.	1	Clover hay and 3 lbs of grain per day	15280	1782	25.7	3.	22.8	2.66	9.57	8.49
Dec. 20 to March 29, 99 days	2	Clover hay and 5 lbs of grain per day	15025	2912	25.2	5.	28.	5.43	11.55	12.79
	3	Clover hay and 7 lbs of grain per day	14745	3942	24.8	6.63	22.5	6.02	13.16	11.94
	4	Clover hay and 10 lbs of grain per day	13115	5315	22.1	9.	18.6	7.53	14.97	12.55
Whole time.	1	Clover hay and 3 lbs of grain per day	19710	1942	25.4	2.50	19.2	1.89	8.9	6.7
Nov. 21 to Mar. 29, 129 days	2	Clover hay and 5 lbs of grain per day	19423	3072	25.	3.96	21.5	3.41	10.4	8.9
	3	Clover hay and 7 lbs of grain per day	19115	4102	24.6	5.29	18.4	3.97	11.7	8.6
	4	Clover hay and 10 lbs of grain per day	17435	5475	22.5	7.07	16.4	5.16	13.	9.5
Total for 24 steers.			75683	14591						
Average for 1 steer.			3153	608	24.4	4.70	18.9	3.81	11.0	8.4

pound of increase in live weight. These figures afford a very interesting comparison of the relative value of the various rations.

Put into money value we find that the cost of each pound of gain ranged from 8.49c for lot I up to 12.55c for lot IV—a difference of 4c in favor of the lighter grain ration. For lot II, fed 5 pounds of grain per day, each pound of gain cost more than did the gain on lot IV, fed the larger grain ration. As noted above the steers in lot II, for some reason, did not do very well.

Considering, next, the whole time of the test, which will include the 30 days preliminary feeding, when hay was mainly fed, and but little grain, we find that this preliminary period materially helps out the cost of feeding. It will be noted by referring to table I that the gains made during this first, or preliminary period, were on the average much faster than the gains made during the 99 days test period. We find also that the amount of hay and grain eaten per day per steer and for each pound of gain in live weight was considerably less than during the experimental period. During this preliminary period the cost of one pound of gain in live weight averaged about 3.4 cents per pound, compared with 8½ to 12½ cts. per pound during the experimental period. The effect of this, as stated before, is to materially reduce the cost of feeding for the whole time of the experiment. The hay eaten per day by the steers, on the average for the 129 days, was practically the same as for the experimental period, but the grain ration ranges from 2.5 to 7 pounds, which is considerably lower than for the experimental period. The food eaten for each pound of gain is considerably less, both in clover and in grain, ranging from 2 to 7 pounds less hay and from .7 to nearly 2 pounds less grain.

Considering the average of the car-lot we found that the steers ate 24.4 pounds of hay and 4.7 pounds of grain per day. The food eaten for one pound of gain averaged 18.9 pounds of clover and 3.81 pounds of grain. The cost of feeding averaged for the car-lot 8.4 cents for each pound of gain in live weight. These results, as will be noted by referring to the first experiment reported in this bulletin and to previous years' tests, are considerably more expensive gains than we have previously had in our feeding tests. This is true even of the smallest grain ration, viz: three pounds per day.

FINANCIAL RESULT OF THE TEST.

Table No. 3 gives the financial statement and the summary for this test. It presents, in another way, several facts given in the previous tables. The steers, on the average, cost $28.00 each, but to put all on an even basis, they are figured at a calculated rate of $2.58 per hundred pounds. In this way we get the correct cost of each lot of steers as determined from their beginning weights.

The average cost of feeding each steer, for the 129 days, ranged from $9.47, for lot I, to $14.76 for lot IV—a difference of $5.43 per steer in favor of lot I, which was fed the light grain ration. The average cost per steer for the carload was $12.16. The total cost of feeding the carload was $291.89.

TABLE No. III—FINANCIAL STATEMENT AND SUMMARY, 1904-5

	Lot 1. Clover & 3 lbs, of gr'n.	Lot II. Clover & 5 lbs. of gr'n.	Lot III Clover & 7 lbs. of gr'n.	Lot IV Clover & 10 lbs of gr'n.	Average and tot'ls
Nnmber of steers	6	6	6	6	24
Weight at beginning....lbs.	6546	6488	6553	6490	26077
Cost of steers at 2.58c per lb	$169.00	$167.40	$169.60	$168.00	$674.00
Cost of food per lot	56.91	68.14	78.25	88.59	291.89
Cost of food per steer	9.47	11.36	13 04	14.76	12.16
Total cost of steers	225.91	235.54	247.85	256.59	965.89
Weight at close of test....lbs.	7570	7386	7590	7556	301.02
Net gain in pounds....lbs.	1024	898	1037	1066	4025
Rec'd for steers, shrunk w'ght, 3.5c lb	267.96	261.45	268.67	267.46	1065.54
Received per head for steers	44.66	43.58	44.78	46.58	44.40
Profit on each lot and total profit	42.05	25.91	20.82	10.87	99.55
Profit or loss on each steer	7.01	4.32	3.45	1.81	4.15

These steers sold for 3.5 cents per pound, shrunk weight, which was nearly 1 cent above the purchase price. The price received per steer ranged from $43.58 for lot II to $46.38 for lot IV. The average price received for the steers was $44.40 at Bozeman. The profit on each steer in the lot tells an interesting story. On lot I the profit was $42.05. On lot II it was $25.91. On lot III the profit was $20.82, and on lot IV only $10.87. The profit on each steer ranged from $7.01 for lot I, which was fed on the light grain ration, down to $1.81, for the steers fed the heavy grain ration, or, in other words, the steers fed the light grain ration returned nearly four times the profit obtained on lot IV, fed the heavy grain ration.

WHERE DOES THE PROFIT COME FROM?

In Bulletin 48 it is stated that the profit in feeding the steers we have handled has been due to the difference between the buying and selling price of the steers, rather than to any profit made on the increase put upon the animals while feeding.

The above table, No. 4, which gives the cost price of the steers, the selling price, and cost per pound of gain for six years, from 1900 to 1905, inclusive, fully illustrates this point. In only two instances was the cost of the gain less than the selling price of the steers, namely: For lot I, in 1901, and for lot I in 1902. Yet in every year, except for 1903 and 1904, there was a profit over market prices made on the steers, and in 1903 the loss was very little, namely, $6.00 on the car lot or 25 cents on each steer. In 1904 the loss was greater. A pertinent question is, what is the least difference between the buying and selling price that will afford a safe margin when feeding for profit? In 1903 the steers practically paid for their feed. The difference between the buying and selling price was 35 cents per hundred. In 1904 the difference between the buying and selling price was only 30 cents per hundred pounds, and the loss on the car load was $40.51, or $1.26 per steer. In 1900 the difference between the buying and selling price was 78 cents per hundred pounds and the profit on the car load was $77.93, or on each steer $4.87. In 1901 the difference between the buying and selling price was 95 cents and the profit on the car load was $122.59 and for each steer $3.95. In 1902 the difference between the buying and selling price was $1.17 per hundred pounds and the profit on the car load was $168.68 or $7.66 for each steer. In 1905 the difference between the buying and the selling price was 92 cents per hundred pounds, and the profit on the car load was $99.55, or for each steer $4.15.

While we cannot neglect the commercial factor of buying and selling in considering the profit in feeding steers, yet the cost of the ration may mean very much on the financial returns. In 1900 the difference in the cost of 100 pounds of gain, between the cheapest and most expensive ration, was $1.28. In 1901 the difference was 46 cents per hundred pounds. In 1902 it was $1.80 per hundred pounds. In 1903 it was $1.97 per hundred pounds and in 1904 the difference was 87 cents per hundred pounds, and in 1905 the difference was $2.80 per hundred pounds.

If we estimate that the steers gained 200 pounds each during

TABLE No. IV.—A Comparison Between the Cost and Selling Price of the Steers, with the cost of Each Pound of Gain for the Six Years from 1900 to 1905.

	* 1900.			† 1901.			‡ 1902.		
Lot..........	Cost of steers per lb.	Steers sold per lb....	Cost of one lb. gain	Cost of steers per lb.	Steers sold per lb....	Cost of one lb. gain	Cost of steers per lb.	Steers sold per lb...	Cost of one lb. gain
	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.
1	3.47	4.25	6.12	3.17	4.12	4.85	3.14	4.33	4.
2	3.47	4.25	4.84	3.17	4.12	5.16	3.14	4.33	4.81
3	3.47	4.25	5.56	3.17	4.12	5.31	3.14	4.33	5.80
4									

	§ 1903.			1904.			1905.		
Lot..........	Cost of steers per lb.	Steers sold per lb.....	Cost of one lb. gain	Cost of steers per lb.	Steers sold per lb.....	Cost of one lb. gain	Cost of Steers per lb	Steers sold per lb...	Cost of one lb. gain.
	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.
1	3.65	4.	5.90	3.2	3.5	5.33	2.58	3.5	6.7
2	3.65	4.	6.13	3.2	3.5	5.01	2.58	3.5	8.9
3	3.65	4.	4.81	3.2	3.5	4.86	2.58	3.5	8.6
4	3.65	4.	4.17	3.2	3.5	4.56	2.58	3.5	9.5

* See Bulletin No. 27. † See Bulletin No. 31.
‡ See Bulletin No. 35. § See Bulletin No. 48.

the winter, and nearly all those steers did better than that, the difference in the cost quoted would mean a difference in the returns of from 92 cents to $5.60 on one steer, or a difference of $92.00 to $560.00 more profit on 100 steers, according to the ration fed. These facts are certainly worth considering.

Yet another point to consider is the cost of these gains compared to the cost in the east. A recent Iowa bulletin (No. 79) gives the cost of feeding steers per pound of increase where a large number of steers were considered as follows: Fifty steers were fed in a lot and the cost of each pound of gain ranged from 7.88 cents to 9.45 cents in 1903 and from 9.65 cents to 11.08 cents in 1902.

Except for 1905 the results obtained by the Montana Experiment Station were very much below those above quoted from Iowa. These steers wer fed during the various winters from 101 to 139 days and the average daily gain was over two pounds per day, as will be noted in another place in this bulletin. It will also be noted that these gains are made on a much lighter grain ration than is usual in the corn districts. These results afford much encouragement to the Montana feeder who finishes his cattle before sending them to the eastern market. The six years covered by these tests have been an area of low prices for cattle, so that the returns have not been large compared with the returns from feeding sheep. However, they have, in the main, been on the right side, which should be encouraging, because more propitious times are surely coming.

SUMMARY.

Experiment for 1903-4.

(1.) The results of the tests made during the winter 1902-3 and 1903-4 seemed to show that the relative value of the different grains, (when fed with clover) to produce increase in live weight on a steer, is: 1st, mixed grain; 2d, barley; 3d, wheat; 4th, oats. See page 62.

(2.) Considering the food required for each pound of gain the relative value of the different grains, when fed with clover, is as follows: 1st, mixed grain; 2d, wheat; 3d, barley; 4th, oats. See page 63.

(3.) With the cost of grain and hay, as reported in this bulletin, the relative value of these grains was as follows, starting with the lowest or cheapest ration: 1st, mixed grain; 2d, barley: 3d, wheat; 4th, oats. See page 66.

(4.) These steers cost 3.2 cents per lb. live weight and sold for 3.5 cents per lb. Considering this difference between the buying and selling price and the cost of the grain and hay fed, these steers failed to pay for their feed by $40.51, which represented a loss of $1.26 on each steer. See page 67.

Experiment for 1904-5.

(1.) In this test while the steers fed the larger grain ration gained more and faster than those fed the smaller grain ration, yet the gains were in no wise in proportion to the difference in the grain. Steers fed 7 and 10 pounds of grain a day gained an average of but two pounds more each than those fed three pounds of grain per day over a period of 99 days. See table I., page 71.

(2.) The food required for each pound of gain ranged from 22.8 lbs. of hay and 2.66 lbs. of grain for lot I, and 18.6 lbs. of hay and 7.53 lbs. of grain. This represents a displacing of the cheap hay by the more expensive grain, which, with prices as they are with us, does not tend towards economy of production. See page 74.

(3.) Put into money value, the cost of each pound of gain ranged from 8.49 cents for lot I, up to 12.55 cents for lot IV, a difference of 4 cents in favor of the light grain ration. See page 74.

(4.) On the average for 129 days each steer in this carlot ate 24.4 pounds of hay and 4.7 pounds of grain per day. They required 18.9 pounds of hay and 3.81 pounds of grain for each pound of increase in live weight, and the cost of this increase averaged 8.4 cents per pound. See page 74.

(5.) These steers cost 2.58 cents per pound and sold for 3.5 cents per pound live weight. With this difference and considering the cost of the food, the profit on the food given each steer of this car was as follows:

Lot I, fed 3 pounds of grain..........	$7.31 each.
Lot II, fed 5 pounds of grain............	4.32 each.
Lot III, fed 7 pounds of grain............	3.45 each.
Lot IV, fed 10 pounds of grain............	1.81 each.

(6.) In the experiments conducted in feeding a car lot of steers for the past six years, in but one year, and then with but one lot, has the selling price of the steers equaled the cost of the gain. The profit is a business matter and must come from selling the animal at an advanced price per pound over the buying price. The better condition of the animal generally makes it possible to get this extra price. Page 76.

(7.) The above fact does not make less important the necessity for the investigations to find the most efficient and cheapest ration. For the six years during which these tests have run, the difference in cost between the rations fed for the various years would mean a difference of from $92.00 to $560.00 more profit on 100 steers. See page 77.

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MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

F. B. LINFIELD, DIRECTOR

BULLETIN NO. 59

SHEEP FEEDING

FOR THE YEARS 1904 AND 1905

BY

F. B. LINFIELD
Animal Industry

BOZEMAN, MONTANA
NOVEMBER
1905

MONTANA AGRICULTURAL COLLEGE EXPERIMENT STATION

BOZEMAN, MONTANA

Post Office, Express and Freight Station, Bozeman.

All communications to the Experiment Station should be addressed to

THE MONTANA EXPERIMENT STATION,
Bozeman, Montana.

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SHEEP FEEDING EXPERIMENTS FOk 1903-4.

INTRODUCTION.

The Montana Experiment Station has fed a car load of sheep each winter since the year 1898, and, up to date, therefore, has fed for seven seasons. The last report published of this work was Bulletin No. 47, in which, on some points, a summary was given of the work previously done. This work was continued for the season of 1903-4 and 1904-5, and the results of this work will be reported herewith.

The experiment for the winter of 1903-4 was a repetition of that of the year before, although with not quite as good a grade of stock. The sheep, both the lambs and the wethers, fed during the winter of 1902-3 were an extra fine lot, containing considerable of mutton blood upon a Merino foundation. They were good, thrifty stock when they arrived on the station farm, and a month's feeding upon the grain and hay fields of the farm put them into the feed lots in extra fine condition. At the end of the season they had, therefore, the size and fatness to command the top price on the market. However, there are many other classes of stock in the state and it is our purpose to learn all we can about these various grades and classes.

NUMBER AND KIND OF SHEEP PURCHASED.

The sheep purchased for the experiment of the winter of 1903-4 consisted of 120 lambs, which cost us $1.79 3-10 each delivered at Bozeman, and 120 two-year-old wethers, which cost us $2.56 each at Bozeman. They were selected and purchased for us by Mr. John M. Robinson, of Bozeman, to whom we are indebted for this favor. No special attempt was made to select any especial grade of stock, but they were taken out of a larger bunch just as they would come. They were delivered at the station farm on the 3rd

of November and turned out upon the grain and hay fields. The fall and summer had been quite dry, however, so that there was but little feed upon the fields and in two weeks the sheep were put into the feed lots. When they came upon the station farm the wethers averaged 113 pounds, and two weeks later, when put into the feed lots, they weighed 119½ pounds each, gaining 6½ pounds on the pasture. This may have been partly due to a fill-up, as well as to some increase in weight. The lambs weighed 54 pounds each when they arrived on the farm and 57½ pounds when put into the feed lots two weeks later. It will be noted that these weights were considerably below the weights of the stock fed the year before, when the wethers weighed 123 pounds at the beginning of the test and the lambs 70 pounds. These weights also show that the lambs were light for the season of the year and they were not equal in quality to those of the year before, but in breeding were somewhat similar, being Merino grades with a greater or less mixture of mutton blood. The wethers were also light in weight but were a little better in condition and quality than the lambs.

KIND AND PRICES OF FEED.

In this portion of Gallatin Valley the principal hay is red and alsike clover, usually mixed in various proportions. With the summer weather we usually have, this hay may be easily cured, saving a large proportion of the leaves and stems and is thus of very good quality. We usually have considerable new meadow, as we seed about 15 to 20 acres every year in following a systematic rotation on the farm. This leaves quite a large amount of old stubble on the hay field, more or less of which is raked up with the first crop of clover. As the animals refuse to eat those dead stalks, it means considerable waste when feeding this first crop of hay, which was the main crop fed to those sheep. Again the winter of 1903-4 was quite a snowy winter. As we have no place to store our hay under cover it is stored in stacks and the snow and wet interferred considerably with the getting of a correct or exact weight of the hay fed. It is believed, however, that the results given are fairly accurate and if an error there be, it is on the side of increasing rather than decreasing the cost of the feeding. The grains fed, except the screenings, were grown upon the farm and were fed whole. The

screenings were purchased from a local grist mill, and consisted of considerable broken wheat, and weed seeds of very many kinds. The prices allowed for these feeds are the average prices for the winter and were as follows: Clover hay, $5.00 per ton; wheat screenings, 85c. per cwt.; wheat, $1.25 per cwt.; oats, $1.00 per cwt.; barley, $1.00 per cwt. The sheep were fed in yards which, in one end, had a covered shelter and on the other end running water. The sheep, therefore, were at liberty to seek the shelter whenever they desired to do so, which we found to be very seldom. They also had access to water at will.

THE WEIGHING OF THE SHEEP.

All farm animals vary considerable in weight from day to day depending upon the contents of the digestive organs. To avoid the errors that might arise from this variation, the animals were weighed three days in succession at the beginning of the experiment and again at the end. It is usual, also, to weigh them once or twice every two weeks to note the growth of the animals, so as to keep a careful check on the results while in progress. The weights in this test were taken right after noon, which would be some hours after the morning's feed.

PLAN OF THE EXPERIMENT.

The purpose of the experiment was similar to that of the year before. In addition to determining the general facts in regard to the value of clover as sheep feed and the gains that might be made upon our range flocks during the feeding period in the winter, it was also desired to find the feeding value of the different kinds of grains and mixtures of grains available to the Montana farmer.

The sheep, therefore, were divided into ten lots, 5 lots of lambs and 5 lots of wethers. There were 24 sheep in each lot.

The lambs were fed as follows: Lot 1, clover hay and wheat screenings;lot 2 clover hay and wheat; lot 3, clover hay and oats; lot 4, clover hay and barley; lot 5 clover hay and a mixture of grains, made up of equal parts by weight of wheat, oats and barley. The five lots of wethers were numbered correspondingly and fed the same as the lambs.

The clover was fed *ab libitum*, our idea being to feed what the animals would eat up fairly clean. As stated above, the first

TABLE 1 WEIGHTS AND GAINS FOR WETHERS. 1903-4.

Period.	Lot.	How lots were fed	No. of wethers.	Weight at beginning of period.	Weight at end of period.	Gain in live weight.	Aver'ge gain per day per lot.	Aver'ge gain per day per wether.	Average weekly gain per wether	Aver'ge gain per each wether.
1st. period 25 days Nov. 20 to Dec. 15	1	Clover hay & wheat screenings	24	2880	3017	137	5.48	.228	1.59	5.70
" " " " " " "	2	Clover hay & wheat	24	2895	3022	127	5.08	.221	1.547	5.29
" " " " " " "	3	Clover hay and oats	24	2868	3010	142	5.68	.236	1.652	5.91
" " " " " " "	4	Clover hay and barley	24	2840	2955	115	4.60	.191	1.337	4.79
" " " " " " "	5	Clover hay and mixed grain	24	2868	2997	129	5.16	.215	1.505	5.37
2d period 28 days Dec. 16 to Jan. 13	1		24	3017	3075	58	2.07	.086	.602	2.41
" " " " " "	2		24	3022	3137	115	4.10	.170	1.190	4.79
" " " " " "	3	Same as above	24	3010	3120	110	3.92	.163	1.141	4.58
" " " " " "	4		24	2955	3075	120	4.28	.178	1.246	5.00
" " " " " "	5		24	2997	3092	95	3.39	.141	.987	3.95
3d period 44 days Jan. 14 to Feb. 26	1		24	3075	3325	250	5.68	.236	1.652	10.41
" " " " " "	2		24	3137	3407	270	6.13	.255	1.785	11.25
" " " " " "	3	Same as above	24	3120	3340	220	5.00	.208	1.456	9.16
" " " " " "	4		24	3075	3317	242	5.50	.229	1.603	10.00
" " " " " "	5		24	3092	3305	213	4.84	.201	1.407	8.87
Whole period 97 days	1		24	2880	3325	445	4.58	.190	1.330	18.54
" " "	2		24	2895	3407	512	5.27	.219	1.533	21.33
" " "	3	Same as above	24	2868	3340	472	4.86	.202	1.414	19.66
" " "	4		24	2840	3317	477	4.91	.204	1.428	19.87
" " "	5		24	2868	3305	437	4.50	.187	1.309	18.03
Total and average for all lots			120	14351	16694	2343	24.12			
Average for one wether				119.5	139.1	19.5		.2	1.402	19.48

TABLE II. FOOD EATEN AND COST OF FOOD FOR WETHERS. 1903-4.

Period.	Lot.	How lots were fed	Number of Wethers.	Clover Fed. Lbs.	Clover Waste Lbs.	Clover Eaten Lbs.	Grain Eaten. Lbs.	F'd eaten per d'y per wether. Cl'r	F'd eaten per d'y per wether. Gr'n	Food eaten per 1 lb gain. Lbs cl'r	Food eaten per 1 lb gain. Lbs grn	Cost per wether per day. Cents.	Cost of 1 lb. gain. Cents.
1st period 25 days, Nov. 20 to Dec. 15	1	Clover & wheat scre'ngs	24	3015	466	2549		4.24		18.5		1.06	4.62
	2	Clover & wheat	24	3015	467	2548		4.23		20.0		1.06	5.00
	3	Clover and oats.........	24	3015	445	2570		4.28		18.0		1.07	4.50
	4	Clover and barley	24	3015	404	2611		4.35		22.7		1.09	5.67
	5	Clover and mixed grain	24	3015	432	2583		4.30		20.0		1.08	5.00
2d period 28 days, Dec. 16 to Jan. 13	1		24	3035	650	2385	401	3.55	.596	41.1	6.91	1.39	16.15
	2		24	3035	530	2505	401	3.72	.596	21.7	3.48	1.67	9.77
	3	Same a above	24	3035	515	2520	401	3.75	.596	22.9	3.64	1.53	9.37
	4		24	3035	486	2549	401	3.79	.596	21.2	3.34	1.54	8.64
	5		24	3035	467	2568	401	3.82	.596	27.	4.22	1.60	11.33
3d period 44 days, Jan. 14 to Feb. 26	1		24	4950	1283	3667	1056	3.47	1.	14.6	4.22	1.72	7.24
	2		24	4950	1186	3764	056	3.56	1.	13.9	3.91	2.14	8.36
	3	Same a above	24	4950	1134	3816	056	3.61	1.	17.3	4.80	1.90	9.13
	4		24	4950	1204	3746	1056	3.54	1.	15.5	4.36	1.88	8.23
	5		24	4950	1099	3851	1056	3.64	1.	18.	4.95	1.99	9.84
Whole period 97 days	1		24	11000	2399	8601	1457	3.69	.625	19.3	3.26	1.45	7.49
	2		24	11000	2183	8917	1457	3.83	.625	17.4	2.84	1.74	7.90
	3	Same as above	24	11000	2094	8906	1457	3.82	.625	18.8	3.09	1.58	7.79
	4		24	11000	2094	8906	1457	3.82	.625	18.7	3.05	1.58	7.72
	5		24	11000	1998	9002	457	3.86	.625	20.5	3.33	1.64	8.73
Average and totals for all lots			120	55000	10768	44332	7285	3.81	.625	18.94	3.11	1.60	7.92

crop of hay, which made a large portion of the feed given, contained considerable stems and, as will be noted in the tables there was some waste. We started feeding grain three weeks after the beginning of the experiment. At first but a small grain ration was given, and we had to coax the sheep to eat it, first by reducing slightly on their hay so as to make them a little more hungry, and next by salting the grain slightly. Six pounds were given to each lot per day at the start and one month was taken to get the animals to the maximum ration of one pound per sheep per day. In weighing up the sheep we planned to divide the lots as evenly as possible, both according to weight and quality, so that each might start off on as fair a basis as possible.

DISCUSSION OF RESULTS.

WEIGHT OF WETHERS.

Table No. 1 gives the weights and gains of the wethers. It will be noticed that they were fed for 97 days, this time being divided into three periods, first 25, second 28 and the last 44 days. This table also shows the gain for each lot per day and of each animal per day, per week and for the whole time of the test.

Comparing, first, by periods, it will be noticed that the wethers made the fastest gains during the first and third periods, though the first may have been somewhat of a "fill-up." This is shown particularly in the average, which was about .22 lbs. per day for each lamb. This result is true of practically all the lots. Considering next, the results from the different kinds of grain, it will be noticed that on the wheat ration the wethers gained during the 97 days 21.33 pounds each. The next best returns were from the barley ration, upon which they gained 19.87 pounds. Then follows the oats, screenings, and the mixed grain last. This result is somewhat different from the previous year, in which we found the barley to be the best ration, followed by the oats, wheat, screenings and mixed grain. The only difference, however, when we analyze carefully is the transposition of the wheat and barley. The other results are almost exactly the same as reported in bulletin 47. Taking the two years, therefore, together, it would seem that the barley or wheat proved the most satisfactory ration for feeding wethers, though the oats were very close third.

Considering the whole time of the test, it will be noticed that the wethers made an average daily gain of only .2 of a pound. This was about .03 of a pound less than the wethers gained the previous year. The average total gain for each wether was 19.48 pounds, or, in round numbers, 19½ pounds, which was three pounds less than that gained the year before.

AMOUNT OF FOOD EATEN BY WETHERS.

Table No. 2 shows the total amount of food eaten, the food eaten per day and the cost of each pound of gain. During the first period, when the sheep had no grain whatever, they ate an average of about 4¼ pound of hay per day. The range was from 4.35 to 4.23 pounds per day. When the grain ration was added the amount of hay eaten fell off from a half to three-fourths of a pound per day, and on a full grain ration they ate fully ¾ pound less hay per day than on hay alone, but the total amount of food eaten was greater as they were at that time eating one pound of grain per day.

The average amount of hay eaten per day for the different lots during the 97 days was practically the same, and for all the lots the average was 3.81 pounds per day.The wethers received no grain for the first 25 days of the test and for the next 28 days averaged nearly .6 of a pound per day. The last 44 days of the test they each received 1 pound of grain per day. The average grain received for the 97 days of the feeding was .625 of a pound, or a little over ½ pound per day.

THE FOOD EATEN FOR EACH POUND OF GAIN BY WETHERS.

The food eaten for each pound of gain, gives some very interesting facts. For the first period from 18 to 22.7 pounds of clover hay were eaten for each pound of gain made. For the second period, when the grain ration was added, it required from 21 to 41 pounds of hay in addition to the grain to make one pound gain. The third period, however, this was reduced to from 13.9 to 18 pound of hay for each pound of gain, in addition to the grain. The average for the whole period showed that 18.94, or, in round numbers, 19 pounds of hay and 3.11 of grain were required for each

pound of gain. Comparing the different results it will be noticed that the sheep fed on the wheat ration required the least amount of feed for each pound of gain, viz: 17.4 and 2.84 pounds of grain, The oats and barley rations are practically the same. For the screenings ration 19.3 pounds of clover and 3.26 pounds of grain were required for one pound of gain, while for the mixed grain ration, 20.5 pounds of clover and 3.33 pounds of grain were required, making the mixed grain ration the most expensive. For the third or test period, the wheat returns was the most efficient, requiring 13.9 lbs, of clover and 3.91 lbs. of grain for each lb. of gain. The screenings, barley, oats and mixture followed in the order named.

COST OF FOOD EATEN BY WETHERS.

Because of the variation in the price of both hay and grain during different seasons, and more especially in the different parts of the state, the money cost of the gain is not always a safe point from which the feeders in other valleys might calculate the returns. In consideration of these differences in price, the amount of food eaten for each pound of gain is a much safer basis upon which to calculate the cost of the gain. From this data each person of every district can figure exactly what it will cost to produce the gain whatever the difference in price in these different districts might be.

With the prices given in this bulletin it cost on the average 1.6 cents per day to feed each wether. The wheat ration, because of the cost of the grain, was the most expensive. For the same reason the mixed grain ration was next expensive, while the screenings ration was the least expensive. Considering the cost of the feed for 97 days the average shows that it cost close to eight cents (7.92) to produce each pound of gain on these wethers. The range was from 7.49 for the screenings ration to 8.73 for those fed the mixed grain ration. The barley, oats and wheat come between in the order named, the wheat ration being the most expensive of the three. For the test period of 44 days the screenings ration produced a pound of gain for the least cost, followed by the barley, wheat, oats and mixture in order named.

TABLE III. WEIGHTS AND GAINS OF LAMBS. 1904-5.

Period.	Lot.	How lots were fed	No. of Lambs.	Wght beginning of period. Lbs.	Weight at end of period. Lbs.	Gain in live weight. Lbs.	Av. gain per d'y per lot. Lbs.	Av. gain per d'y per lamb. Lbs.	Av. weekly gain per lamb. Lbs.	Aver'ge gain per lamb. Lbs.
1st period 25 days Nov. 20 to Dec. 15	1	Clover and wheat screenings...	24	1373	1497	124	4.96	.206	1.42	5.16
" " " " " "	2	Clover and wheat	24	1380	1505	125	5.	.208	1.45	5.20
" " " " " "	3	Clover and oats..	24	1381	1487	106	4.24	.176	1.23	4.41
" " " " " "	4	Clover and barley	24	1368	1462	94	3.76	.156	1.09	3.91
" " " " " "	5	Clover and mixed grain	24	1391	1480	89	3.56	.148	1.03	3.70
2d period 28 days Dec. 16 to Jan. 13	1	Clover and wheat screenings...	24	1497	1645	148	5.28	.220	1.54	6.16
" " " " " "	2	Clover and wheat	24	1505	1620	115	4.10	.170	1.19	4.79
" " " " " "	3	Clover and oats..	24	1487	1640	153	5.46	.227	1.58	6.37
" " " " " "	4	Clover and barley	24	1462	1622	160	5.71	.237	1.65	6.66
" " " " " "	5	Clover and mixed grain	24	1480	1612	132	4.71	.196	1.37	5.50
3d period 44 days, Jan. 14 to Feb. 26	1	Clover and wheat screenings...	24	1645	1970	325	7.38	.307	2.14	13.54
" " " " " "	2	Clover and wheat	24	1620	1892	272	6.18	.257	1.79	11.33
" " " " " "	3	Clover and oats..	24	1640	1955	315	7.15	.295	2.06	13.12
" " " " " "	4	Clover and barley	24	1622	1915	293	6.65	.277	1.93	12.20
" " " " " "	5	Clover and mixed grain	24	1612	1932	320	7.27	.302	2.11	13.33
Whole time 97 days.	1	Clover and wheat screenings...	24	1373	1970	597	6.15	.256	1.79	24.87
" " "	2	Clover and wheat	24	1380	1892	512	5.27	.219	1.53	21.33
" " "	3	Clover and oats..	24	1381	1955	574	5.91	.246	1.72	23.91
" " "	4	Clover and barley	24	1368	1915	547	5.63	.234	1.63	22.79
" " "	5	Clover and mixed grain	24	1391	1932	541	5.56	.231	1.61	22.54
Total and average for all lots			120	6893	9664	2771	28.52			
Average for one lamb				57.4	80.5	23.08		.237	1.65	23.08

TABLE IV. FOOD EATEN AND COST OF FOOD FOR LAMBS. 1904-5.

Period.	Lot.	How lots were fed	No. of Lambs.	Clover Fed. Lbs.	Clover Waste. Lbs.	Clover Eaten. Lbs.	Grain Eaten. Lbs.	F'd eat'n per d'y each lamb. Clo'r	F'd eaten per d'y each lamb. Gr'n	F'd eaten per 1 lb gain. Lbs cl'r	F'd eaten per 1 lb gain. Lbs g'rn	Cost per lamb per day. Cents.	Cost of 1 lb. gain. Cents
1st period	1	Clover & wheat scre'ngs	24	2025	527	1498		2.49		12.08		.62	3.02
Nov. 20 to Dec. 15, 25 days	2	Clover and wheat	24	2025	530	1495		2.49		11.96		.62	2.99
	3	Clover and oats	24	2025	488	1537		2.56		14.50		.64	3.62
	4	Clover and barley	24	2025	464	1561		2.60		16.60		.65	4.15
	5	Clover and mixed grain	24	2025	511	1514		2.52		16.90		.63	4.22
2nd period	1		24	1840	585	1255	401	1.86	.59	8.47	2.70	.96	4.41
Dec. 16 to Jan. 13, 28 days	2		24	1840	553	1287	401	1.91	.59	11.19	3.48	1.21	7.15
	3	Same as above	24	1840	540	1300	401	1.93	.59	8.49	2.62	1.07	4.84
	4		24	1840	465	1375	401	2.04	.59	8.59	2.50	1.10	4.65
	5		24	1840	515	1325	401	1.97	.59	10.03	3.03	1.13	5.78
3d period	1		24	2625	1251	1374	1056	1.30	1.	4.22	3.24	1.17	3.80
Jan. 14 to Feb. 26, 44 days	2		24	2630	1260	1370	1056	1.29	1.	5.03	3.88	1.57	6.11
	3	Same a above	24	2630	1227	1403	1056	1.32	1.	4.45	3.35	1.33	4.46
	4		24	2625	1190	1435	1056	1.35	1.	4.89	3.60	1.34	4.82
	5		24	2630	1276	1354	1056	1.27	1.	4.23	3.30	1.40	4.62
Whole period 97 days	1		24	6490	2363	4127	1457	1.77	.62	6.91	2.44	.97	3.80
	2		24	6495	2343	4152	1457	1.78	.62	8.10	2.84	1.22	5.57
	3	Same a above	24	6495	2255	4240	1457	1.82	.62	7.38	2.53	1.07	4.37
	4		24	6490	2117	4371	1457	1.87	.62	7.99	2.66	1.09	4.66
	5		24	6495	2286	4193	1457	1.80	.62	7.75	2.69	1.12	4.66
Average and totals for all the lots			120	32465	11364	21083	7285	1.81	.62	7.62	2.63	1.09	4.61

WEIGHT OF LAMBS.

Table No. 3 gives the weight of the lambs and the gains made during the time of the test. When put into the feeding lots the lambs averaged 57.4 pounds and at the end of the feeding period weighed an average of 80.5 pounds, a gain of 23 pounds in the 97 days. The year before the lambs gained an average of 25 pounds, weighing 70 pounds at the beginning of the test. In proportion to their beginning weight, therefore, these lambs gained proportionally more than the lambs did the year before. It is well to bear this fact in mind when we come to consider the final results with these lambs. The average gain per day made by each lamb was .237 pounds. Considering the results for the different kinds of rations fed it will be noticed that the lambs fed on the screenings made the largest gains, namely: .256 pounds per day. This result coincides with previous tests, as recorded in Bulletin 47, and in work previously done by the writer in Utah. The next largest return was from the oat ration, namely: .246 pound per day. Next follows the barley, then the mixed grain, and lastly the wheat gives the poorest results. The year before the order was screenings, mixed grain, wheat, barley and oats. There is scarcely enough difference in any of the results, however, to base very marked conclusions upon, and the test should be repeated before we can conclusively state which of these grains would be the best except with regards to the screenings, which, for lambs, seems to be preferable to any other grain. Comparing the gains by periods it will be noticed that the screenings ration made the most uniform gains throughout all the periods. During the third period, when the maximum ration was fed, the lambs made the fastest gain, ranging from .257 pounds to .307 pounds per day. During the third period which might be called the true experimental period the order of the grains for the different rations was as follows: First, the screenings; second, the mixed grain; third, the oats; fourth, the barley, and the wheat the poorest returns. This is nearer the results of the year before than if we consider the whole time of the feeding. It is too the correct basis upon which to base the relative value of the gains as a part of the fattening ration for sheep.

AMOUNT OF FOOD EATEN BY LAMBS.

Table No. 4 shows the food eaten and the cost of the food given to the lambs. On the average each lamb ate 1.81 pounds of hay and .62 pounds of grain per day. During the first period, when no grain was fed, the amount of clover hay averaged close to 2.5 pounds per day. When the grain was added the hay ration was reduced in almost direct proportion to the amount of grain added, and the same thing is true in the third period, when the full grain ration is given. There is very little difference between the amount eaten by the lambs getting the various kinds of grain.

FOOD EATEN FOR EACH POUND OF GAIN BY LAMBS.

The food eaten for each pound of gain by the lambs averaged 7.62 pounds of hay and 2.63 pounds of grain. The range was from 6.91 pounds of hay and 2.44 pounds of grain for the lambs fed on the screenings ration to 8.10 pounds of hay and 2.84 pounds of grain for the lambs fed upon the wheat ration. The oats, mixed grain and barley follow in the order named between these two extremes. Considering the third period, 44 days, when the full grain ration was fed, we find that the wheat ration called for the largest amount of clover and grain for each pound of gain. The barley was the next most expensive in feed, the oat ration third and the mixed grain and screenings the cheapest ration as regarding the amount of feed required. When fed on clover hay alone, as during the first period, it will be noticed that it took from 12 to nearly 17 pounds of hay to make each pound of gain. When the grain ration was added about 3½ pounds of grain displaced close to 10 pounds of clover, as will be noticed in the third period. The difficulty with lambs which are growing is to get them to eat enough clover to fatten in anything like a reasonable time. Therefore, the grain ration has to be added. These tests do not pretend to show the amount of grain that would give the best results.

COST OF FOOD EATEN BY LAMBS.

The cost of food is given so that comparisons can be made on this basis, but the food cost mentioned above should be kept in mind. The average cost of feeding each lamb per day for the 97 days was 1.09 cents. The cost of each pound of the gain was 4.61 cents. This

cost was a little above that of the year before, which was 4.49 cents. The grain during this season, however, was more expensive than the year before, as will be noticed by comparing the cost of the feed given in bulletin 47 with that reported in this bulletin. If we compare the amount of food eaten for each pound of gain, it will be noticed that these lambs made the more economical gains, requiring .4 of a pound of clover and .5 of a pound of grain less for each pound of gain than did the lambs of the year before. The screenings ration was the least costly, because of the difference in price. The wheat ration was the most costly again because of the higher price of this grain.

Table V. Comparison of Results of Feeding Lambs and Wethers.

Period.	Food eaten per day. Lbs clover	Food eaten per day. Lbs grain	F'd eaten per 1 lb gain. Lbs cl'r	F'd eaten per 1 lb gain. lbs gr'n	Gain per day per sheep. Lbs.	Total gain per sheep. Lbs.	Cost of food per day. Cents.	Cost of 1 lb of gain. Cents.	Total cost of g'n per sheep. $
Lambs	1.85	.62	7.62	2.63	.237	23.08	1.	4.61	.98
Wethers	3.81	.625	18.94	3.11	.2	19.5	1.6	7.92	1.54

COMPARISON OF RESULTS WITH LAMBS AND WETHERS.

Table No. 5 gives a brief comparison of the results in the feeding of the lambs and wethers. It will be noticed that the amount of grain eaten per day was practically the same for each, but the wethers ate two pounds more of hay per day than did the lambs. Considering the amount of food eaten for one pound of gain the wethers ate 11 1-3 pounds more clover than did the lambs and nearly half a pound of grain more for each pound of gain made. This shows that the lambs were very much more economical feeders. This is, however, not the only factor to be considered, as will be noticed later. Considering the gain per day the lambs gained .237 pounds to .2 pounds gained by the wethers, or, for the total time of the test, 97 days, the lambs gained 23.08 and the wethers 19.5 pounds. The cost of the food per day at Bozeman prices was 1 cent for each lamb and 1.6 cents for each wether, and the cost of each pound of gain was 4.61 cents for the lambs and 7.92 cents for the wethers, or 3 1-3 cents more. The total cost of the gain put upon the lambs, during the 97 days of the test, was 98 cents,

while the total cost of the gain put upon the wethers was $1.54, a difference of 56 cents in favor of the lambs. When we consider that the lambs gained 3½ pounds more than the wethers this difference in cost is quite an important one.

THE CLOVER WASTE.

It should not be overlooked, perhaps, that in extensive feeding there is considerable waste on the roughage fed. As stated in another place considerable of the clover fed to these sheep was the first crop. A good deal of it was the first crop after seeding and contained a large amount of old stubble. This would tend to increase the waste as compared to feeding the clover from the second year's meadow. The waste from the wethers was close to 20 per cent of the amount of hay given, and for the lambs it was about 30 per cent of the amount of hay given. It would seem that practicably this waste should be charged to the sheep. However, the most of this was fed to cattle and horses, so that it was not lost, but had a feeding value for other stock which were being carried over and not fattened. In fattening sheep and somewhat forcing the appetite there is sure to be a certain amount of waste, but where it is used for feeding cattle we have not felt that it was necessary to charge this waste against the sheep. However, those who desire to do so can increase the cost of the hay by the figures given.

FINANCIAL RESULTS WITH WETHERS.

Table No. 6 gives a summary of the financial results in feeding wethers. This table shows the essential facts given in the previous tables, but arranged in a different way. This table will repay careful study. It will be noticed that the wethers cost 2¼ cents per pound when purchased, or put into the feed lots. If sold at 4 cents per pound, which was about the price paid in Bozeman, they would return a profit on the feeding of $158.73, or a profit on each wether of $1.32. The cost of the 120 wethers was $323.75. The cost of the feed at the price given was $185.28, which made a total cost of the fattened wethers of $509.03. The price received for the wethers at 4 cents per pound would be $667.6, the difference as given above represents the profit on the feed and pay for the labor. The largest amount of profit on each wether was on the

lot fed on the screenings—$1.42 each. The lot fed on oats returned a profit of $1.33, and that on barley $1.32; the lot fed on wheat $1.27 and of mixed grain $1.26 for each wether.

TABLE IV. SUMMARY AND FINANCIAL RESULTS OF FEEDING WETHERS, '03-4

Fed 97 Days.	Lot I.	Lot II.	Lot III.	Lot IV	Lot V.	Total and average.
Number of lambs	24	24	24	24	24	120
Weight at beginning lbs.	2880	2895	2868	2840	2868	14351
Cost of wethers at 2.25c per lb.	$ 64.97	$ 65.31	$ 64.70	$ 64.07	$ 64.70	$ 323.75
Cost of feed	33.88	40.50	36.83	36.83	37.24	185.28
Total cost of fattened wethers	98.85	105.81	101.53	100.90	101.94	509.03
Weight at close of test lbs.	3325	3407	3340	3317	3305	16694
Net gain lbs.	445	512	472	477	437	2346
Average gain for wethers lbs.	18.54	21.33	19.66	19.87	18.03	19.48
Rec'd for wethers if sold for 4c per lb.	$133.00	$136.28	$133.60	$132.68	$162.20	$667.76
Profit on feeding	34.15	30.47	32.07	31.78	30.26	158.73
Profit on one wether	1.42	1.27	1.33	1.32	1.26	1.32
Weight of wethers in Chicago lbs.	.....	.....	.....	.....	.....	15888
Loss of weight in shipping	.....	.....	.....	.....	.....	806
Per cent loss in shipping per cent.	.....	.....	.....	.....	.....	5
Received for wethers at 5 ¼c per lb.	.....	.....	.....	.....	.....	$834.12
Total cost of shipping with commission	.....	.....	.....	.....	.....	132.45
Cost of shipping one wether	.....	.....	.....	.....	.....	1.10
Net returns for wethers	.....	.....	.....	.....	.....	691.67
Cost of wethers and feed	.....	.....	.....	.....	.....	509.03
Profit on feeding	.....	.....	.....	.....	.....	182.64
Profit on feeding one wether	.....	.....	.....	.....	.....	1.52

THE SHIPPING EXPERIENCE.

The second part of this table gives some data in regard to the results from shipping the sheep to Chicago. Comparing the weights at the close of the test with the weights in Chicago, we find that the wethers lost 806 pounds in shipping. This was 5 per cent. which was considerably below the losses reported on the lot shipped the year before, which was 7 per cent. These wethers sold for 5¼ cents per pound, which gave a gross return of $834.12. The total cost of shipping, with commission, was $132.45. The lambs and wethers, of course, were shipped together, but the charges were made in proportion to the weight of the animals shipped. The cost of shipping one wether was, therefore, $1.10. The net returns for the wethers, after deducting the cost of shipping, was $691.67, which left a profit on the feeding of $182.64, or $1.52 for each wether. This shows a return of 20 cents more per wether than would have been obtained by selling the wethers at home.

THE FINANCIAL RESULT WITH LAMBS.

Table No. 7 gives a summary of the financial result with the lambs. The lambs cost 3.32 cents per pound, which was a little more than 1 cent per pound more than was paid for the wethers. The lambs were not in as good flesh as the wethers, and so were not reckoned as worth any more per pound at Bozeman. Selling at 4 cents we get a return of $386.56. The 120 lambs cost $229.30 and the feed cost $128.07, thus making the total cost of the fattened lambs, $357.37, which, compared with the returns at 4 cents per pound, gave a profit of $29.19, or 24.5 cents for each lamb. This is a very small profit and probably no more than paid for the labor in looking after the animals. By comparing the different lots we find that the lambs fed the screenings returned a profit of 44 cents each, while those fed on the wheat ration returned but 5 cents profit each. The other results are between those.

THE SHIPPING EXPERIENCE.

Considering next the shipping experience we find that the lambs, during the time of shipping to Chicago, lost 438 pounds, or 4.6 per cent of their Bozeman weight. This was again lower than the year before by about 3 per cent. This shows a very small shrinkage from both the lambs and the wethers. The lambs sold in Chicago at $5.15 per hundred, which, it will be noticed, was 10

cents per hundred less than was obtained for the wethers. The gross return, therefore, was $471.01. The cost of shipping, with commission, was $88.15, or 73½ cents each, which was about the same as for the previous year. The net return for the lambs, therefore, was $382.86, which gave a profit of $25.49, or 21 cents profit on each lamb. This brings us to consider a very interesting question, namely: Why the lambs, which were the most economical feeders, returned the least profit on the feeding. In the previous year's test the wethers had sold in Chicago for $6.00 per hundred

TABLE VII. SUMMARY AND FINANCIAL RESULTS OF FEEDING LAMBS. '03-4

Fed for 97 Days	Lot I.	Lot II.	Lot III.	Lot IV.	Lot V.	Total and average.
Number of lambs	24	24	24	24	24	120
Weight at beginning ... lbs.	1373	1380	1381	1368	1391	6893
Cost of lambs at 3.323c per lb.	$ 45.61	$ 45.85	$46.18	$ 45.45	$ 46.21	$ 229.30
Cost of feed	22.60	28.59	25.17	25.50	26.21	128.07
Total cost of fattened lambs	68.21	74.44	71.35	70.95	72.42	357.37
Weight at close of test ... lbs.	1970	1892	1955	1915	1932	9664
Net gain ... lbs.	597	512	574	547	541	2771
Average gain per lamb ... lbs.	24.87	21.33	23.91	22.79	22.54	23.08
Rec'd for lambs if sold for 4c per lb.	$78.80	$75.68	$78.20	$76.60	$77.28	$386.36
Profit on feeding	10.59	1.24	6.85	5.65	4.86	29.19
Profit on one lamb	.44	.5	.28	.24	.20	.24½
Weight of lambs in Chicago ... lbs.	...	...	...	...	...	9126
Loss of weight in shipping ... lbs.	...	...	...	...	...	438
Per cent loss in shipping ... per cent.	...	...	...	...	...	4.6
Rec'd for lambs at $5.15 per cwt.	...	...	...	...	...	$ 471.01
Total cost of shipping with commission	...	...	...	...	...	88.15
Cost of shipping one lamb	...	...	...	...	...	.73½
Net return for lambs	...	...	...	...	...	382.86
Cost of lambs and feed	...	...	...	...	...	357.37
Profit on feeding	...	...	...	...	...	25.49
Profit on feeding one lamb	...	...	...	...	...	.21

and the lambs for \$7.25 per hundred pounds, a difference of \$1.25 per hundred pounds in favor of the lambs. This is the usual difference when both are equally fat and ready for the market. It will be noticed, also, by comparing the price paid for the lambs, both in the year 1902 and 1903, as well as in the test here reported, that the lambs cost more per pound than the wethers. The difference is greater for this year than for the previous year, when it was but 25 cents per hundred pounds, whereas this year it was a little over one cent per pound different. The lambs fed in this experiment gained as much in proportion to their beginning weight as those of the year before. They were, therefore, just as economical feeders. They also made gains much more economically than did the wethers and yet the financial result shows a decided profit for the wethers and practically none for the lambs, beyond the labor cost of feeding. To get a full explanation why there was this difference I wrote to Clay, Robinson & Company, the commission company who sold the lambs both years, as to the reason for the difference noted. I give herewith this letter from the company, which, in a measure, explains the reason for the difference:

MR. F. B. LINFIELD,

Montana Experiment Station, Bozeman, Montana .

Dear Sir: We are in receipt of your letter of 18th and note what you say regarding the deck of lambs you had here a short time ago.

In reply will say that in the first place they were not heavy enough to command the top price, and, in the second place, they were far from being finished.

If you were here and saw the condition good Colorado lambs were in you would readily agree with us that your lambs are not to be compared with them. We also note you were somewhat surprised that your wethers sold higher than your lambs. These wethers, the day they were here, sold fully 25c above the market. There was an exporter here who simply had to have these sheep, no matter what they cost, and, knowing this, we took advantage of it. In fact \$5.00 would have been a good strong price for these wethers the day they were here.

We candidly believe that you folks could do better with aged wethers out there than with lambs. We do not believe you can fatten your lambs and get them in condition to sell at the top of the

market, unless you happened to strike a market when everybody was crazy for lambs, same as you struck last year. The writer remembers distinctly the day your lambs were here. Every buyer was out hunting lambs, and on a market of that kind we can come nearer getting the top than on a market where there are plenty of good lambs to select from, same as we have had here the last six weeks or two months.

Yours truly,

Clay Robinson & Co.

Note—The underlining is mine.—F. B. L.

It would seem, therefore, that the real trouble with these lambs was that they were not fat enough, and to get the top prices they must be fat. As these lambs gained as much as those did the year before and were fed the same rations and the same length of time then it would seem that the trouble was not in the method of feeding, but rather the lambs were too small to begin with and the time allowed was not sufficient to get these lambs to the weight and condition which would enable them to command the top price. It has been noticed by observing the market that the lambs which come nearest to supplying the demand range from 85 to 95 pounds in Chicago. This would mean a lamb which would weigh something like 95 to 100 pounds in Montana. These lambs were 13 pounds lighter than those fed the year before. To bring them up this much in weight at shipping time would mean that they should be fed for between 50 and 60 days longer. This would seem to indicate that we have to feed larger lambs or else feed them for a longer time if we are to command the best or top price. In comparison with the wethers the lambs grow considerable in addition to the fattening and so make use of a larger amount of the feed given them but in proportion do not put on as much fat as do the wethers. These latter having had their growth turn most of the feed into fat and so get into condition for the market in a shorter time than do the lambs. Again the wethers are stronger and can keep in better condition upon the range than can the lambs and so usually come into the feeding lots in better condition in the fall. Much better results would be obtained with the lambs if they were gotten upon the farm early in the season and had from 6 weeks to two months on the meadow before being put upon the winter ration for fattening.

SHEEP FEEDING TEST FOR WINTER 1904-5.

INTRODUCTION.

During the winter of 1904-5 there was fed at the Experiment Station three lots of sheep. First, we purchased 100 two-year-old wethers. These sheep were grade Merinos with considerable of mutton blood, particularly the Cotswold, in their make-up. These sheep were purchased from Mr. John M. Robinson, of Bozeman, out of a lot of about 900 obtained near Twin Bridges. They were a fairly good grade of sheep, but were rather light. They averaged 110 pounds when weighed at the college farm at delivery, which is the lightest wethers we have fed for the past three years They cost laid down, $3.25 each, which at the weights given, made them cost 3 cents per pound live weight. The wethers were put in pens and fed hay as soon as they arrived on the farm, which was on Nov. 6, 1904. No weights of the feed were kept until Nov. 28, when the experiment started. At this time the wethers weighed 115 pounds, having gained 5 pounds in about 20 days.

The second lot of sheep handled were 64 head, the remainder of a lot which our chemist had been working with, during the summer, on the range near Big Timber, testing, in co-operation with the Department of Agriculture, some problems in relation to the effect of loco weed upon the sheep. They were a good band of sheep, but some of them had lost weight during the summer. They weighed on the average 83 pounds at the beginning of the test. They were a mixed lot of ewes, wethers and lambs. These we have designated as the "poison-plant" sheep to distinguish them from the other lots.

The third lot of sheep consisted at the beginning of 42 head, but later were reduced, through killing for post-mortem purposes and some that died, to 29 head. These animals were very badly "locoed", as the symptoms for this trouble are usually described. The

animals were scarcely strong enough to drive from the railroad station to the college farm. They weighed an average of 42½ pounds each and were a mixed lot of ewes and lambs, with Merino blood predominating. These were designated as the "locoed" sheep. These latter two lots were fed in co-operation with the chemical department and in a bulletin, soon to be issued from that department, full details in regard to the study of the individual sheep and the treatment and deductions drawn from the experiment during the summer and winter will be given. Our plan was to find out what results could be obtained from feeding this class of sheep as compared to a fairly good class of wethers, using these latter as a basis for comparison.

PLAN OF THE EXPERIMENT.

The three kinds of sheep were divided into two lots each. The "poison plant" sheep contained 32 in each lot. In lot one was the stronger and heavier sheep and in lot two the lighter and presumably weaker sheep. Lot one received clover hay and one pound of grain per day as a maximum grain ration. Lot two received clover hay, 1 pound of grain per day and ½ pound of roots per day as a maximum ration. The "locoed sheep" were also divided into two lots. The first called, lot 3, was made up of the stronger sheep, and the second, called lot 2, was made up of the lighter and weaker sheep, our plan being to feed those sheep so as to encourage, if possible, the lighter sheep through our method of feeding. Lot 3 received clover hay, 1 pound of screenings a day and ½ pound of roots as a maximum ration. Lot 4 received the same ration except that mixed grain was substituted in place of the screenings. The grain for both the "poison-plant" and "locoed" sheep was crushed coarsely. The 100 wethers were also divided into two lots, 50 in a lot, and they were divided as nearly equal as possible, considering the weight and quality of the sheep. The first, known as lot 5, received clover hay and 1½ pound of grain per day and the 2d, known as lot 6, received clover hay and 1 lb. of grain a day Our purpose in this was to get a comparative test of the effect of the lighter or heavier grain ration. For these sheep the grain was fed whole. The grain fed consisted in every case of a mixture of ½ barley, ¼ oats and ¼ bran, by weight. The clover hay was a

mixture of first and second crop red and alsike clover. The roots fed were mainly sugar beets, with occasionally some mangolds.

The animals were fed all the hay they would eat, which was given them twice a day. For the first five days of the test hay alone was fed, and then the grain was started, giving 1-5 of a pound of grain to each sheep. This was gradually increased until the full amount specified was given. At the beginning the grain was given but once a day, but as the amount was increased it was given twice a day. The roots were given at the same time as the grain. At first the sheep did not take readily to the roots. Later we changed from sliced to pulp roots and the sheep ate the ration very much better. Fresh water was running through the yards at all times so that the sheep had ready access to a water supply.

WEIGHING THE SHEEP.

The sheep were weighed as in previous tests, each lot being weighed three days in succession at the beginning of the experiment and again when on full feed and once in two weeks thereafter till the close of the test, when they were again weighed three days in succession. They were weighed on Monday, as soon as possible after noon. It will be noted, therefore, that the weights given at the beginning and end of the test are not a single day weighing but the average of three days weighing in succession, which should give very close to a correct average.

VALUE OF THE FOOD.

The values estimated for the hay and grain fed are given so as to afford a basis of comparison with others, whose prices may be more or less different. The prices are as follows: Clover hay, $5.00 per ton; barley, $1.00 per hundred pounds; oats, $1.00 per hundred pounds; bran, 95c. per hundred pounds; and roots, $4.00 per ton.

As the studies of the chemical department had shown that many of these sheep were probably affected with internal parasites, all of the "poison plant" and "locoed" sheep were treated with vermifuges. A full account of the methods and results on this point, will be discussed in a later bulletin by that department.

TABLE NO. 1 WEIGHTS AND GAINS OF WETHERS, "LOCOED" AND "POISON PLANT" SHEEP. 1904-5.

Period.	Lot.	How lots were fed	No. of Sheep.	Weight at beginn'g of period.	Weight at end of period.	Gain in Live Weight.	Av'rge gain per day per lot.	Av'ge gain per day per sheep	Av. weekly gain per sheep.	Aver'ge gain for each sheep.
Poison Plant Sheep										
1st period Nov. 28 to Jan. 4, 38 days	1	Clover hay and grain.........	32	2880	3090	210	5.53	.172	1.20	6.59
" " " "	2	Clover had grain and roots....	32	2420	2620	200	5.26	.164	1.15	6.25
2d period Jan. 5, to Jan. 31, 27 days	1	Clover hay and grain.........	32	3090	3285	195	7.22	.225	1.59	6.09
" " " "	2	Clover hay grain and roots....	32	2620	2847	227	8.41	.263	1.84	7.09
Whole time of test 65 days	1	Clover hay and grain.........	32	2880	3285	405	6.26	.195	1.35	12.7
" " "	2	Clover hay grain and roots....	32	2420	2847	427	6.57	.205	1.43	13.3
Locoed Sheep										
1st period Nov. 28. to Jan. 4, 38 days	3	Clover hay screenings & roots	16	697	855	158	4.15	.259	1.81	9.87
" " " "	4	Clover hay grain and roots...	14	579	752	173	4.55	.325	2.27	12.35
2d period Jan. 5, to Jan. 31, 27 days	3	Clover hay screenings & roots	15	820	850	30	1.11	.074	.52	2.
" " " "	4	Clover hay grain and roots...	14	752	852	100	3.71	.265	1.85	7.14
Whole time of test 65 days	3	Clover hay screenings & roots	15	662	850	188	2.89	.193	1.35	12.5
" " "	4	Clover hay grain and roots...	14	579	852	273	4.20	.3	2.1	19.5
Feb, 1 to Mar. 30, 58 days........	3&4	Clover hay grain and roots....	29	1702	2060	358	6.17	.213	1.49	12.3
Whole time of test with locoed sheep 123 days	3&4	Clover hay grain and roots....	29	1241	2060	819	6.66	.229	1.61	28.2
Wethers										
1st period Nov. 28, to Jan. 4, 38 days	5	Clover hay and half lb. grain..	50	5748	6037	289	7.60	.152	1.064	5.78
" " " "	6	Clover hay and 1 lb. grain	50	5758	6082	324	8.52	.170	1.192	6.48
2d period Jan. 5, to Jan. 31, 27 days	5	Clover hay and half lb. grain..	50	6037	6425	388	14.37	.287	2.011	7.76
" " " "	6	Clover hay and 1 lb. grain	50	6082	6417	335	12.40	.248	1.736	6.70
Whole time of test 65 days	5	Clover hay and half lb. grain..	50	5784	6425	677	10.41	.208	1.457	13.54
" " "	6	Clover hay and 1 lb. grain	50	5758	6417	659	10.13	.202	1.418	13.18

DISCUSSION OF RESULTS.

WEIGHTS AND GAINS OF SHEEP.

Table No. 1 gives the weights and gains of the sheep feed in this test. It will be noticed that these different lots vary in the number of sheep in each, and so comparisons will have to be based on the daily gain and the average gain for each animal. On the average it will be noticed that the wethers gained .205 pounds per day for the sixty-five days of the test. Compared with the year before this is a very slightly larger daily gain. Each wether of lot 5 gained 13.54 pounds and each one of lot 6 gained 13.18 pounds. The wethers weighed an average of 115 pounds at the beginning of the test and 128½ pounds at the close, and thus gained on the average 13.36 pounds. Strange to say the ration of ½ pound of grain per day gave a little the larger gain. At present I can offer no explanations of this rather unexpected result. Further tests will have to be made before drawing any definite conclusions. If later tests should bear out this result it would have a very important bearing upon the practice of feeding in this state. It will be noticed that during the second period, when the sheep were on a full grain ration, they gained nearly 1-10 of a pound more per day than during the first period, when the smaller grain ration was fed. However, even for this period the sheep fed the small grain ration made the larger daily gains. Lot 1 and 2, the "poison plant" sheep, were classified, as stated above, according to the grade of the sheep, the lighter sheep being put into one lot and the larger and heavier in the other. There was a difference of 460 pounds between the two lots. In the 65 days lot 1, the stronger sheep, gained 405 pounds. and lot 2, the weaker sheep, gained 427 pounds, or 22 per cent more than the heavier sheep. The average daily gain per sheep was about .2 of a pound, and the average gain per sheep for the 65 days was 13 pounds. This, it will be noted, is but very little less on the average than the gains made by the wethers in the same time. In this test the addition of roots to the ration of the lighter sheep seemed to have helped them to make considerably better gains. It will also be noticed that during the second period, when the full grain ration was given, better gains were made than during the first period.

Considering, next, the third group, the "locoed" sheep, we find

that there was a difference of 118 pounds between the two lots. The lighter sheep, in lot 4, weighed 579 pounds and the heavier sheep, in lot 3, weighed 697 pounds. In 65 days lot 3, the heavier sheep gained but .193 pounds per day, but lot 4, the lighter sheep, gained 3 lbs. per day, or more than 1-3 greater gain. The total gain was 188 pounds for lot 3 in 65 days and 273 pounds for lot 4, a difference of 85 pounds. Each sheep of lot 3 gained 12½ pounds and of lot 4 gained 19½ lbs., or 6 lbs. more. The only difference in the ration was that lot 3 received screenings. Both got the same kind and amount of roots.

The average gain for those "locoed" sheep was 16 pounds each for the 65 days.

This was considerably more than the gain made by the "poison plant" sheep, and 2.3 pounds more than the average gained by the wethers in the same time. The test would seem to show that the so-called "locoed" sheep, if properly treated, will gain as rapidly as other sheep. This is not the whole story, however,. They gained more, yet they were so thin to begin with, only 42½ pounds each, that the 16 pounds of gain only made them weigh 58½ pounds. They were thus too light and too poor to go into the market when the other sheep were shipped.

These two lots (3 and 4) were therefore fed for another 58 days. During this time they each gained .213 pounds per day or 12.3 pounds for the 58 days. During this time they were fed the same as before, namely: clover, grain and roots. This gain was greater than the average gain of wethers or "poison plant" sheep for the first 65 days of the feeding test.

Considering the 123 days during which the locoed sheep were fed they made a gain of .229 pounds per day and added 28.2 pounds to the 42.5 pounds original weight. These gains also compare very favorably with the gains made by the sheep the two previous years, as recorded in bulletin 47, and in the first part of this bulletin.

TABLE NO 2. Food Eaten and Cost of Food For Wethers, Locoed and "Poison Plant" Sheep. 1904-5.

Period.	Lot.	No. of Sheep.	Clover Fed. Lbs	Clover Waste Lbs	Clover eaten Lbs	Roots eaten Lbs	Grain eaten Lbs	F'd eaten per d'y per sheep. Clov'r	F'd eaten per d'y per sheep. Grain	F'd eaten per d'y per sheep. Roots	F'd eaten per 1 lb. gain. Clover	F'd eaten per 1 lb. gain. Grain.	F'd eaten per 1 lb. gain. Roots	Cost per day per sheep. Cents.	Cost of 1 lb of gain. Cents
Poison Plant Sheep.															
1st period Nov. 28 to Jan. 4, 38 days	1	32	4835	985	3850		551	3.16	.45		18.33	2.62		1.24	7.2
" " " "	2	32	4470	2058	2412	416	551	1.98	.45	.34	12.06	2.75	2.08	1.01	6.3
2d period Jan. 5 to Jan. 31, 27 days	1	32	2700	605	2095		864	2.42	1.		10.74	4.43		1.6	7.3
" " " "	2	32	2700	795	1905	432	864	2.20	1.	.5	8.39	3.79	1.90	1.65	6.4
" " " "	1	32	7535	1590	5945		1415	2.85	.68		14.66	3.49		1.39	7.3
" " " "	2	32	7170	2853	4317	848	1415	2.07	.68	.4	10.09	3.31	1.98	1.28	6.4
Locoed Sheep.															
1st period Nov. 28 to Jan. 4, 38 days	3	16	1405	568	837	208	412	1.37	.67	.34	5.29	2.60	1.31	1.07	3.9
" " " "	4	14	1415	567	848	208	412	1.59	.77	.39	4.90	2.38	1.20	1.22	3.9
2d period Jan. 5, to Jan. 31, 27 days	3	15	830	388	442	344	325	1.09	.8	.84	14.73	10.83	11.46	1.24	5.7
" " " "	4	14	830	387	443	344	325	1.17	.85	.91	4.43	3.25	3.44	1.32	5.2
Whole time of test 65 days	3	15	2235	956	1279	552	737	1.31	.75	.56	6.80	3.02	2.93	1.19	6.2
" " " "	4	14	2245	954	1291	552	737	1.41	.80	.60	4.72	2.69	2.02	1.27	4.4
Feb. 1 to March 30, 58 days.......	& 4	29			2284	985	1315	1.35	.78	.58	6.37	3.64	2.75	1.23	5.7
Whole time of test Nov. 28 to March 30, 123 days............	3& 4	29			4854	2089	2789	1.36	.77	.58	5.92	3.40	2.55	1.23	5.4
Wethers															
1st period Nov. 28 to Jan. 4, 38 days	5	50	8079	690	7389		553	3.88	.29		25.56	1.91		1.26	8.4
" " " "	6	50	8070	1075	6995		710	3.68	.37		21.58	2.19		1.30	7.7
2d period Jan. 5 to Jan. 31, 27 days	5	50	5950	880	5070		675	3.75	.5		13.06	1.73		1.44	5.0
" " " "	6	50	5935	925	5010		1310	3.71	.97		14.95	3.91		1.9	7.8
Whole time of test 65 days	5	50	14029	1570	12459		1228	3.83	.37		18.40	1.81		1.33	6.5
" " " "	6	50	14005	2000	12005		1720	3.69	.52		18.21	2.61		1.44	7.3

Lot 1 -Fed clover hay and grain. Lot 3—Clover hay, scree'ngs and roots. Lot 5—Clover hay and ½lb grain daily.
Lot 2 Fed clover hay, grain and roots. Lot 4- Clover hay, grain and roots. Lot 6—Clover hay and 1lb. grain daily,

AMOUNT AND COST OF FOOD EATEN BY SHEEP.

Table No. 2 gives the amount and cost of the food eaten by the sheep in the experiment during the winter 1904-5. The wethers in lot 5 received one-half of a pound of grain per day as a maximum ration, while lot 6 received one pound per day as a maximum. However the two lots were started with the same amount of grain and this amount was gradually increased, at the same proportion for each, from 1-5 of a pound per day to one half of a pound for lot 5 and to 1 pound for lot 6. The result was that lot 6 ate 492 pounds of grain more than lot 5. It will also be noticed that lot 5 ate 454 pounds of hay more than did lot 6. The difference in the hay eaten, however, is greater in the first period than in the second period. when there was a maximum difference in the grain. On the average for 65 days lot 5, with a light grain ration, required 18.4 pounds of clover and 1.81 pounds of grain for each pound ot increase in live weight, while lot 6, with a heavier grain ration, required 18.21 pounds of clover and 2.61 pounds of grain for each pound of gain. This shows a saving of .8 pound of grain by feeding the light grain ration. Considering the cost of the gain at the prices of feed given the light grain ration saved .8 cents for each pound of gain made. This is certainly a very interesting result, but as this is the first test we have made upon this point it would be wise to withhold any definite conclusions until the test has been repeated.

Considering, next, the "poison plant" sheep, we find that lot 1, the heavier and stronger sheep, ate much more hay, namely, 1,438 pounds, than lot 2 during the first period. The weaker lot did not clean up their hay and there was thus a large amount of waste. For the second period the difference is less. To compensate for 1,628 pounds less of hay eaten by lot 2 during the 65 days they had 848 pounds of roots. Both lots ate the same amount of grain. Lot 1 ate an average of 2.85 pounds of hay and .68 pounds of grain per day, which was 1 pound less hay than eaten by the wethers. Lot 2 ate 2.07 pounds of hay per day and .68 pounds of grain. Considering the food eaten for each pound of gain we find that lot 1 required 14.66 pounds of hay and 3.49 pounds of grain for each pound of increase in live weight, while lot 2, the weaker sheep, required but 10.09 pounds of clover and 3.31 pounds of grain for each pound of

increase in live weight. They ate, however, 1.98 or nearly 2 pounds of roots. Thus it would appear that this small amount of roots made a saving of about 4½ pounds of hay. Compared with the wethers which had the full grain ration, lot 1, the stronger sheep cost 7.3 cents for each pound of gain, which was exactly the cost for each pound of gain for the wethers fed the maximum grain ration. Lot 2, the lighter sheep, which had the most roots, cost but 6.4 cents for each pound of gain, which was practically the same as the wethers fed the lighter grain ration. Coming, next, to the "locoed" sheep we have to consider that we are dealing with small animals, weighing only about one-half as much as those in the "poison-plant" lot or only about one-third the weight at the beginning of the test. These small sheep would naturally be small feeders. They ate an average of 1.36 lbs. of hay per day, which was 2 pounds less than the wethers ate and 1 pound less than the "poison plant" sheep ate. They ate slightly more grain per day and about .6 of a pound of roots.

FOOD EATEN FOR EACH POUND GAIN.

Considering, next, the food eaten for each pound of gain it will be noticed that lot 3, the heavier sheep, ate 6.8 pounds of hay, 3.92 pounds of grain and 2.93 pounds of roots for each pound of gain. while the lighter sheep required but 4.72 pounds of hay, 2.69 pounds of grain and 2.02 pounds of roots for each pound of gain. This shows a saving of 2.08 pounds of hay, .2 pounds of grain and .9 pounds of roots, as compared with the "poison plant" sheep and the wethers. It will be noticed that the "locoed sheep required very much less hay for each pound of gain than did the wethers, but on the average they required slightly more grain. Considering the prices of the feed, the lightest lot (4) of the "locoed" sheep made the cheapest gains, namely, 4.4 cents for each pound of gain. Lot 3, the heavier sheep, cost 6.2 cents for each pound of gain, which was about the same as the cost on the light weight "poison plant" sheep. Each pound of gain put upon the wether or "poison plant" sheep cost 6.9 cents, while for the "locoed" sheep this cost was 5.3 cents, or 1.6 cents less, which seems to show that the locoed sheep will gain as economically as the stronger and better sheep if properly fed and treated.

SECOND PART OF EXPERIMENT WITH LOCOED SHEEP.

Considering, next, the continuation of the experiment with locoed sheep; as noted above they were not ready for the market and were thus fed for 58 days longer. They received practically the same amount of feed as for the second period of the first part of the test, though the hay during this time was not weighed. During this period of 58 days it required 6.37 pounds of hay, 3.64 pounds of grain and 2.75 pounds of roots for each pound of gain. Each pound of gain cost 5.7 cents, which was practically the same as for the first 65 days of the test. For the 123 days, during which these sheep were fed, it required 5.92 pounds of hay, 3.40 pounds of grain and 2.55 pounds of roots to produce each pound of gain put upon the sheep. The average cost of this gain was practically the same as for the previous part of the test.

The results which were obtained with these "locoed" sheep were a surprise to the writer, as they probably will be to many other feeders, and the question arises, why this difference in the experience noted?" I will not enter into any discussion as to what is the cause of "loco" in sheep as this matter will be fully discussed by Prof. Chesnut in a bulletin soon to be issued. It has been noted above, however, that practically all of those "locoed" sheep were more or less affected with internal parasites, and even if there were no other cause, these parasites, together with hard fare on the range, and especially so with lambs, would give us a starved and very thin animal. Even on very good feed I have known animals to pine and die when affected with internal parasites of various kinds. How much worse the condition of those animals with the range feed as it frequently is? Attention has been called to the fact that these sheep were treated with vermifuges. These, of necessity, have to be strong medicins, and, as was stated before, the "locoed" sheep were very week. Some of them died the first night after they reached the farm from exhaustion and others died a few days later before being treated with vermifuges. A few others died after this treatment. Of the 42 head obtained but 29 survived to the end of the test, though nearly half of those lost were killed for post-mortem examinations. It is probable, however, that the treatment with vermifuges may have en-

abled the sheep that survived to make better gains than they would have otherwise have done.

There is yet another point to be considered in the feeding of this class of sheep. Although they made as rapid gains and as economic gains, in fact a little better on both points than any of the other sheep, yet they were far from being ready for the market when the other sheep were shipped, and to have sold them at this time would have necessitated selling at a considerable sacrifice, because of the very poor condition at this time. Such sheep must be kept on feed for some time longer than sheep not so affected.

Table No. 3. Summary and Financia Results in Feeding Sheep. 1904-5.

	Lot 1. Fed clover and mixed grain.	Lot 2. Fed clover, gr'n and roots.	Lots 3 and 4 Fed clover, gr'n and roots.	Lot 5. Fed clover and ¼ lb. grain	Lot 6. Fed clover and 1 lb. grain.
No. of days red	65	65	123	65	65
No. of sheep	32	32	29	50	50
Weight at beginning ....lbs.	2880	2420	1241	5748	5753
*Cost of sheep	$ 86.40	$ 72.60	$ 29.00	$172.44	$ 172.64
Cost of food	29.01	26.63	44.22	43.43	47.31
Total cost of fattened sheep	115.41	99.23	73.22	215.87	219.95
Weight at close of test ....lbs.	3285	2847	2060	6425	6417
Net gain ....lbs.	405	427	819	677	659
Average gain per sheep ....lbs.	12.7	13.3	28.2	13.54	13.18
**Received for sheep	$131.40	$113.88	$94.05	$257.00	$256.68
Profit on feeding	16.00	14.65	20.73	41.22	36.73
Profit on one sheep	.50	.46	.71	.82	.73

*The cost of lots 1, 2, 5, and 6 is figured at three cents per lb., but the sheep in lots 3 and 4 are figured at $1.00 each.

**The sheep in lots 1, 2, 5, and 6 were sold for 4c per lb. live weight. After being shorn the sheep in lots 3 and 4 sold for 3 ½c per lb. To this was added the value of the wool at 22c per lb.

FINANCIAL RESULTS WITH SHEEP.

Table No. 3 gives a summary and the financial result in feeding sheep for the winter of 1904-5. In this table lots 3 and 4 are figured together as one lot as they were fed practically the same during the time of the test, and for the second part of the experiment with these sheep they were fed together. In figuring the cost of the sheep, lots 1 and 2 and 5 and 6 are estimated at 3 cents per pound. This was the actual cost of lots 5 and 6. Lots 1 and 2, when purchased in the spring of 1904 cost considerably more than the price here stated, but the experiment in the summer decreased their value, and I think the estimated value given will be fully high enough for the class of stock. The "locoed" sheep were figured at one dollar per head, which was practically the cost of having them laid down at Bozeman. They were donated to us by Mr. J. F. Ashbury of Big Timber, and the cost to us was merely the freight to get the sheep to Bozeman. The experiment with lots 1, 2, 5 and 6 continued for 65 days, when the sheep were sold. Lots 3 and 4 were fed for 123 days. The various items considered in this table are very interesting and worthy of study. In summing up the profits on the feeding, it will be noticed that the wethers gave a little the largest profit. This was due to the fact that these animals weighed more and the increase in price on the original weight of the animals from 3 to 4 cents made really more than the difference in the profits noted in lots 1 and 2 and 5 and 6. After paying market prices for the feed, these sheep returned 46 to 50 cents each for lots 1 and 2 and 82 to 73 cents for lots 5 and 6. Lots 3 and 4 (the "locoed" sheep), after feeding for 123 days, sold for $94.03, giving on the 29 sheep a return of $20.73, or 71 cents per head. This shows that such sheep, if properly handled and fed long enough to get them in condition, can be fed at a profit.

SUMMARY AND CONCLUSIONS.

(1) For feeding wethers and when fed with clover hay, wheat and barley gave the fastest gains, followed by oats, screenings and mixed grain in the order named. See page 90.

(2) Considering the amount of food required for each pound of gain in feeding wethers, wheat and clover was the most efficient ration, followed by screenings, barley, oats and mixed grain in order named. See page 92.

(3) In feeding lambs screenings and clover gave the fastest gains, followed by mixed grain, oats, barley and wheat, in order given. See page 95.

(4) The amount of food required for each pound of gain on lambs was least for the ration of screenings and clover, with oats, mixed grain, barley and wheat in the order named. See page 96.

(5) Lambs gain faster and more economically than do wethers. See page 97.

(6) The light, thin lamb cannot be fattened sufficiently in three months to command the best price in the market. See pages 100-103.

(7) In one experiment in feeding 100 wethers for 65 days, 50 wethers fed a maximum ration of ½ pound of grain a day gained as rapidly as 50 wethers fed 1 pound grain a day as a maximum ration.

(8) A band of 29 "locoed" sheep that had been treated with vermifuges fed during 123 days gained as rapidly and made as economic gains as a band of healthy wethers. Being small and thin, however, they would have to be fed at least twice as long to get them ready for the market.

Montana Agricultural College Experiment Station.

F. B. LINFIELD, Director.

BULLETIN NO. 60.

ONION GROWING

A PRELIMINARY REPORT

BY
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BOZEMAN, MONTANA
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1905

MONTANA AGRICULTURAL COLLEGE
EXPERIMENT STATION

BOZEMAN, MONTANA

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ONION GROWING IN MONTANA.

INTRODUCTION.

This bulletin gives the results of three year's tests with onions, made at the Experiment Station in the years 1903, 1904 and 1905.

It is often said, and not without some truth, that Montana grown onions will not keep. According to the variety, it takes onions from 135 to 150 days to mature from seed, and of course if they are not thoroughly ripe their keeping quality is injured. It quite frequently happens that there are not more than 100 or 120 days between killing frosts in the agricultural valleys of the state, and for that reason it is desirable to practice some system in onion growing other than growing the bulbs directly from seeds planted in the open ground in the spring. Therefore, the following experiments were conducted; the object in view being to test the maturity and the productiveness of several varieties and to determine, if possible, whether onions can be profitably grown in this state.

Each year onion seeds were planted in the green house (which takes the place of a hot bed) in March or April, and transplanted into the field as soon as the ground could be worked. At the time the onions were transplanted, seeds of the same varieties were planted along side the transplanted ones, being grown under exactly the same conditions as to soil, water and cultivation. The first year the onions were grown on fairly good soil, but no fertilizers were given. The second year (1904) the onions were grown on very poor garden soil, without fertilizers, and in 1905 the crop was grown on the same soil that produced onions in 1903; but about one load of coarse hen manure to every square rod of ground was applied. The yields for the three years indicate the value of good soil and manure for onions. The onions were transplanted about

four inches apart in the rows, with the rows 18 inches apart. The seedling onions were thinned to about 4 inches apart, and at that rate there would be 87,120 bulbs per acre.

This was taken as a basis for computing the yields here given.

HOT BED CONSTRUCTION.

To be successful in growing onions, as here outlined, the use of a hot bed is imperative.

FRAME—The frame should afford sufficient protection to keep out cold and rain; one inch material fitted well together will answer the purpose. The sash or top should slope to the south in order to get the afternoon sun. The length of the frame will depend upon the number of plants it is desired to grow, but a bed over five feet wide is inconvenient to plant, water, thin and care for. Some practice driving posts in the ground for the corners, but this is unnecessary and not the best system. Better results being obtained where corner blocks of 2x4 inch material are used, and the ends sawed off flush with the top and bottom of the frame, thus permitting the frame to rest upon the ground or the manure as the case may be. The front board of the frame, or the board on the south side, should be about twelve inches wide, and the back of the frame, if it is five feet wide, should be about 22 inches high, thus giving a slope of two inches to the foot, sufficient to shed rain and to present the maximum surface to the direct rays of the sun.

The sash or covering should, of course, be made to fit the frame, with sufficient length and width to leave a lap of about one inch on either side.

Frames can be purchased from dealers at reasonable prices. Glass 10x12 inches is a good size as it is strong and much cheaper than large sized panes.

PIT—The depth of the pit necessary depends some upon the length of time desired to use artificial heat. If started in March a depth of four feet is not too much, while if started in April two to three feet is sufficient. Good drainage is an essential factor in the hot bed pit, because if the pit becomes too wet it will prevent the manure from heating. The sash should not leak nor the bed be over watered for the same reason. The pit should be about

one foot longer and wider than the frame, otherwise the edges of the bed will be too cold to permit plant growth.

HEATING MATERIAL—The best material to heat the hot bed is fresh manure nearly free from straw, from the horse stable.

Horse manure thrown in a pile will start fermentation or heating even in the coldest weather, therefore it is best to save the manure for the hot bed in thin layers in a dry place until time to use it in the hot bed. Very dry manure should be moistened at the time it is put in the pit. To insure the equal heating of the bed in all parts it is best to start fermentation before placing the manure in the pit. To accomplish this, thorough forking over and repiling the manure is practiced.

It is important to have the material so filled in the pit that it will heat and settle in all parts equally. Very thorough forking and packing will accomplish this.

When the pit has been made a little more than full, the frame can be placed on in a level and solid position and four or five inches more of manure packed in. After this has stood three of four days to permit the escape of the strong ammonia gas add six or eight inches of rich garden soil, to which has been added about one-third its bulk of thoroughly rotted, well pulverized, barnyard manure.

The sides and ends should be well banked with dirt for the purpose of securing surface drainage and for the protection given the frame against cold. The whole surface will probably settle a few inches, but if it has been properly packed no irregularities should appear.

Considerable care should be given the hot bed after the seeds have germinated. If the sashes are not raised during bright sunshine there is danger of burning the plants, and fresh air is essential to the best growth. During very cold weather the frames should be covered, otherwise the plants may freeze. For onions a day temperature of from 65 to 75 degrees should be maintained, with a temperature somewhat lower at night. The plants will have to be watered frequently, care being taken that the ground becomes not too dry nor yet too wet. A few days before transplanting time the sash should be removed in order that the plants may become accustomed to outdoor conditions.

TRANSPLANTING—Onions are an exceedingly easy plant to transplant, yet there are certain features that need attention. If the roots are so long that it is necessary to bend them out of their natural position in transplanting they should be trimmed back. About one-third of the tops should be cut off when transplanted. The method used at the station, is to pick the onions from the hot bed and put them in bunches, trim the roots and tops to the desired length and then place the plants in a pan containing water.

The ground has been previously marked off and a shallow drill made where the onions are to be planted. This drill may be made with a wheel hoe, a hand hoe, or sharp stick. One man takes the pan containing the onions and drops the plants into the drill at the desired distance apart. A second man follows, straightens up the plants and covers the roots, care being taken not to get the bulbs too deep. The onion is one of the easiest of small plants to make grow by transplanting. We have had a very high percentage live when planted under most adverse conditions.

The onions were about one-sixteenth of an inch in diameter when taken from the hot bed.

SEEDING—The onions from seeds planted in the open ground were grown in the following way:

As early in the spring as the ground could be worked, the soil in the onion bed was thoroughly pulverized and leveled. The rows were marked off with a seed marker 18 inches apart and drills about one-fourth inch deep were made. The seeds were planted by hand because of the fact that only small quantities of each variety were being used. In field culture a seed drill could be used to advantage. The seeds were planted about one inch apart in the row and later thinned. If the soil is wet and cold, or if the seeds are planted too deep, they will germinate poorly. Because of this it is necessary to get the surface soil very well pulverized, othewise the depth of planting cannot be regulated, and the soil may get too dry for germination if it is rough and coarse..

After the seeds have all germinated and the plants are large enough to work with they should be thinned. In our practice at the station we thin to four inches apart in order to have them as nearly uniform to the transplanted ones as possible, but in

field culture they could be left closer together.. Three or three and one-half inches would not be to close.

The transplanted and seedling onions were given the same treatment as to cultivation, irrigation and general care, except as has been mentioned.

The ground was kept moist during the early part of the summer and well cultivated. After each irrigation wheel hoes were run between the rows. This was done both to conserve the soil moisture and to keep the soil around the bulbs loose, so that they could make the greatest growth. About the middle of July or the first of August irrigation was stopped, and the dirt cultivated away from the onions. It seems that if the onions are on top of the ground, or nearly so, they will grow larger and mature earlier.

As soon as the tops showed signs of ripening, a light roller was run over the onions, thus breaking down all the tops. This hastens maturity, which is a condition desired in Montana to make onion growing successful.

ONION TESTS FOR 1903.

On April 4, 1903, the seeds of nine varieties of onions were sown in the greenhouse, under conditions practically the same as obtained in the hot bed, with the single exception of the advantage the hot bed gives in ventilation and "hardening off" of the plants before transplanting.

The seeds had germinated by May 5. The plants were left in the seed bed in the greenhouse until May 21, when they were transplanted into the field.

Seeds of the same varieties were planted along side of the transplanted onions on the same date. This being the earliest date that the ground could be successfully worked. The transplanted onions were less than one-sixteenth of an inch in diameter when transplanted. Much better results could have been obtained had the seed been planted in the seed bed earlier. However, even the month's additional growth showed a wonderful increase in production and time of maturity, over the plants grown from seed planted in the open ground.

The following table gives the yields of the transplanted and seedling onions, when grown in rows eighteen inches apart with

the bulbs four inches apart in the rows. In field culture the rows could be closer together, sixteen inches being a convenient distance, and the bulbs could be planted as close as three or three and one-half inches apart. At three by sixteen inches there would be 130,680 bulbs per acre, or 43,560 bulbs more per acre than were used as a basis in computing the yields given in this bulletin.

ONION TESTS—1903.

	Transplanted		Seedlings		
Variety	Av. Wt. per bulb	Yield per acre	Wt. per bulb.	Yield per acre	Per cent. increase
Southport Large Yellow Globe	.47275	41185	.20279	17667	133
Extra Early Flat Red	.44737	38974			
Australian Yellow Globe	.341	29707	.1788	15577	90
Burpee's "Nameless"	.30682	26730			
New Gigantic Gibraltar	.3667	31946	.1379	12013	165
New Mammoth Silver King	.41406	36072	.15385	13403	169
Large Red Globe	.28874	25155	.13776	12001	109
Prize Taker	.3913	34090	.1678	14618	132
Australian Brown	.34836	30349	.18446	16070	88
Adrialtic Barletta			.16873	14699	

It may be seen from the above table, that for the tests for 1903, the Southport Large Yellow Globe variety gave the largest yield per acre from both the transplanted and seedling onions, with an increase of 133 per cent. of transplanted onions over the onions grown from the seeds planted in the field.

The New Mammoth Silver King gave the largest increase of transplanted onions over the seedlings, the increase being 169 per per cent, while the Australian Brown gave the smallest increase, or 88 per cent.

KEEPING QUALITY—These onions were harvested Sept. 30, stored for a time in a shed, where they experienced a temperature of 23 degrees blow zero. On December 29, 1903, they were in the following condition of preservation:

Extra Early Australian Yellow Globe—Both the seedling and transplanted bulbs were in the best possible state of preservation. The bulbs being sound and firm, showing no signs of decay. Among the seedling onions, however, were a large percentage of

thick neck bulbs, which would have to classed as culls in commercial onion growing.

Australian Brown—The transplanted onions were sound and firm. The seedling bulbs were showing signs of becoming soft.

Gigantic Gibralter—Very poor; both the seedling and transplanted onions were soft.

Southport Large Yellow Globe—The transplanted onions were fairly good. Some of the bulbs were showing signs of decay, with but little apparent difference at this date between the transplanted and seedling bulbs.

Large Red Globe—Both transplanted and seedling onions showing some indications of decay.

Silver King—This variety was in a fairly good state of preservation. A few of the bulbs showed some signs of decay. In this variety alone the seedling onions seemed to keep longer than the transplanted ones.

Prize Taker—The transplanted onions were in the best possible condition of preservation. The seedling bulbs showed signs of decay.

We found that the varieties giving the largest yield in 1903 were Large Yellow Globe, Early Flat Red, New Mammoth Silver King and Prize Taker. Those keeping best were Prize Taker, Australian Yellow Globe and Australian Brown. The Prize Taker was among those varieties giving the largest yield and also was among the best varieties in keeping quality, indicating that it is an excellent variety to grow by the transplanting method.

ONION TESTS FOR 1904.

The tests made in 1904 were on very poor soil, as before stated, and the onions were grown without any manures or fertilizers being applied. The yields, therefore, both of the transplanted and seedling onions are much less than in the first and third years of the test.

This year two plantings were made out of doors, the first on May 14 and the second on May 21, at which date the plants from

the hot bed were transplanted. The table following gives the yield of the two seedings and the transplanted onions.

The seeds for the transplanted onions were planted in shallow boxes in the Greenhouse on April 30:

ONION TESTS 1904.

Variety	Seeds Sown May 21		Seeds Sown May 14		Transplanted	
	Wt. per blub pounds	Wt. per acre pounds	Wt. per bulb pounds	Wt. per acre pounds	Wt. per bulb ponds	Wt. per acre, pounds
Yellow Globe Danvers	.134	11674	.164	14287	.1789	15585
Prize Taker	.148	12893	.234	20386	.297	25874
Large Red Globe	.129	11238	.16	13939	.190	16552
White Silver Skin	.116	10105	.133	11586	.23	20037
Golden Globe	.158	13764	.166	14461	.3	26136
Yellow Dutch	.14	12196	.138	11022	.244	21257
Extra Early Red	.1347	11735	.158	13764	.3	26136
Southport Large Yellow Globe	.168	14636	.166	14461	.235	20473
Large Red Wethersfield	.129	11238	.137	11935	.2	17424
Australian Brown	.185	16117	.1855	16160	.331	28836
Extra Early Australian Yellow Globe	.163	14200	.144	12545	.286	24916
Large White Globe	.14	12196	.078	6795	.224	19514
New Mammoth Silver King	049	4268	.071	6185	.197	17162

Much larger yields, no doubt, would have been secured from the transplanted varieties had the seed been planted earlier than April 30. The very poor soil, together with late planting, produced a yield this year much less than in the other years.

The last two varieties in the second column, or the Large White Globe and New Mammoth Silver King, planted on May 14, produced, as shown in the table, but a very small crop. This was due to the fact that they were planted too close to some tall growing vegetables and were shaded. The comparative yield for that reason is not accurate for these two varieties. Most of the varieties show considerable increase in yield when planted early over the later planting, and lead us to believe that if seeds are to be planted out of doors they should be gotten in the ground just as soon as it is possible to get the soil in condition for planting.

Of the transplanted onions, the Australian Brown, Golden Globe, Extra Early Red and Prize Taker gave the largest yields per acre.

ONION TESTS FOR 1905.

In 1905, 18 varieties of onions were included in the test, and the table below gives the size per bulb and yield per acre, figured on a basis of 87120 bulbs per acre, or grown in rows 18 inches apart with the plants four inches apart in the rows. This was the best test yet made, as the conditions for producing an average crop were much better than in former years. Most of the varieties were matured and ready to harvest before killing frosts, which were unusually early this fall:

ONION TESTS. 1905.

Variety	Transplanted		Seedling			Notes
	Av. Wt. per bulb	Yield per acre	Av. Wt. per bulb	Yield per acre	Not Mature Per Cent.	
Large White Globe	.881	76752	.31	27007	22	White, Good for market
Round Yellow Danvers	.578	50355	.285	24829		Yellow, early maturing
New Mammoth Silver King	.733	63858	.346	30143	16	White, matures early. Will not keep
Southport Large Yellow Globe	.691	60199	.346	30143	3.8	Yellow. Large globe shaped bulbs
Extra Early Red	.771	67169	.384	33454	15	Red. Good red onion for market.
Golden Globe	.415	36154	.269	23435	2.95	Yellow, matures early.
Yellow Globe Danvers	.644	56105	.324	28226	8.82	Yellow. Good for market or home use
Prize Taker	.912	79453	.371	32321	12.8	Yellow. Best variety to transplant.
Pink Prize Taker	1.033	89994	.347	30230	25.2	Yellowish pink. Large bulbs.
Extra Early Australian Yellow Globe	.344	29969	.257	22389	14.8	Yellow. Small bulbs.
Yellow Dutch	.666	58021	.325	28314	9.75	Yellow. Fairly good for market.
Michigan	.659	57412	.25	21780	4	Yellow. Matures early.
Large Red Globe	.67	58370	.349	30304	16.9	Red. Late maturing.
Large Red Wethersfield	.751	65427	.339	29533	21.8	Red. Late maturing. Good for market
Australian Brown	.414	36067	.203	17685	4.92	Brown. Matures early; good for mar't
New Gigantic Gibraltar	1.109	96616	.23	20037	61.1	Light yellow. Late maturing.
Improved Early White Queen	.359	31276	.129	11238	1	White. Best for pickling.
White Silver Skin	.587	51139	.258	22476	10.5	White. Medium early.

The varieties giving the largest yields per acre this year, of the transplanted lot, were Gigantic Gibralter, Pink Prize Taker, Prize Taker, Large White Globe, Extra Early Red, Large Red Wethersfield and Silver King. The White Globe and Silver King are white onions and poor keepers, not being well adapted for winter markets. Those best for a commercial market were Prize Taker, with a computed yield of 79453 pounds per acre, Large Red Wethersfield yielding 65427 pounds, and Round Yellow Danvers, which yielded 59067 pounds per acre.

ONION TESTS.—3 YEAR AVERAGES

Variety	1903		1904		1905			
	Transplanted	Seedling	Transplanted	Seedling	Transplanted	Seedling	3 yrs. av. Transplanted Onions	2 years av. Transplanted onions
Large White Globe			19514	6795	76752	27007		48133
Round Yellow Danvers					50355	14932		
Silver King....	36072	13403	17162	6185	63858	30143	39030	
Large Yellow Globe	41185	17667	20473	14461	60199	30143	40622	
Extra Early Red	38974		26136	13764	67169	33454	44093	
Golden Globe			26136	14461	36154	23335		31195
Yellow Globe Danvers ..			15585	14287	56105	28226		35845
Prize Taker	34090	14618	25874	20386	79453	32321	46472	
Pink Prize Taker					89994	30230		
Australian Yellow Globe..	29707	15577	24916	12545	29969	22389	28197	
Yellow Dutch			21257	12022	58021	28314		39639
Michigan					57412	21780		
Large Red Globe	25155	12001	16552	13939	58370	30304	33369	
Large Red Wethersfield..			17424	11935	65427	29533		[illegible]1425
Australian Brown	30349	16070	28836	15117	36067	17685	31750	
Gibraltar	31946	12013			96616	20037		64281
White Queen					31276	11238		
White Silver Skin			20037	11586	51139	22476		35586
Barletta		14699						

In table No. 4 is given the summary of the yields for each year of the test and the average yields for two and three years of both the seedling and transplanted onions. The table shows that the Prize Taker has given the largest average yield of all varieties tested and also has been among the best keepers, although it is not advertised in seed catalogs as a winter onion. The seedling bulbs of this variety keep poorly, because the growing season is not long enough to properly mature them.

SUMMARY.

The soil best adapted to onions is a rich sandy loam, thoroughly pulverized and leveled for irrigating. Once thoroughly prepared onions may be grown to advantage for several years in succession on the same ground, as it divides the cost of the first preparation over several years.

Well rotted manure will materially increase the yield of either the transplanted or seedling onions.

Transplanting will incrase the yield from 50 to 200 per cent, with but little on no increase in the cost of labor.

Transplanting insures an even crop, insures maturity, and thereby the keeping quality of thc onions.